

221
UNITED PLANTERS' ASSOCIATION OF
SOUTHERN INDIA

TEA SCIENTIFIC DEPARTMENT

ANNUAL ADMINISTRATION REPORT

FOR

1935-36



PRINTED BY THE MADRAS PUBLISHING HOUSE LTD.
MADRAS

1936

UNITED PLANTING COMPANY
HAWAIIAN ISLANDS

ANNUAL REPORT

17 AUG. 1936

UNITED PLANTERS' ASSOCIATION OF
SOUTHERN INDIA

ANNUAL REPORT

FOR

1935-36

OF

TEA SCIENTIFIC
DEPARTMENT

COONOOOR

PRINTED BY THE MADRAS PUBLISHING HOUSE LTD.
MADRAS.

1936

TEA SCIENTIFIC DEPARTMENT.

SCIENTIFIC STAFF

Chief Scientific Officer ..W. S. Shaw, D.Sc., Ph.D., M.Sc., F.I.C.

Asst. Tea Scientific Officer ..K. B. W. Jones, Ph.D., B.Sc., A.R.C.Sc., A.I.C.

Entomologist ..S. Ananda Rau, M.Sc.

Mycologist ..M. K. Subba Rao, B.Sc.

Soil Chemist ..V. Jayaraman, B.A., B.Sc. (Ag.)

Temporarily attached:—

Coffee Biochemist ..C. S. Ramanuja Iyengar, B.Sc.

TEA SCIENTIFIC DEPARTMENT

ANNUAL REPORT 1935—1936

Staff:—Resulting from the increased demand for compost analysis and information on soil problems, Mr. V. Jayaraman, B.A., B.Sc., (*Ag.*) was appointed as Soil Chemist in June 1935. The Kanan Devan Planters' Association was chiefly interested in the work of the Soil Chemist, and initially he was deputed to devote himself almost exclusively to compost investigations. To enable him to reside in close proximity to the compost factories, the Kanan Devan Hills Produce Co., Ltd. was prepared to equip a small laboratory in the High Range for his use.

After spending a preliminary training period of two months in analytical technique at the Experimental Station, Mr. Jayaraman proceeded to the High Range, commencing duties there in the first week of August 1935.

In order to deal with the large increase in correspondence and official reports, it was found necessary to employ an Assistant Typist, who took up his duties in October 1935.

The Assistant Tea Scientific Officer was on Home leave from the 26th July 1935, until the 29th January 1936. It is recorded with great pleasure that during this period, Dr. Jones was awarded the degree of Doctor of Philosophy by the University of London for a thesis concerning the Chemistry of Tea.

During this year the Coffee Biochemist was temporarily attached to the Department for training under Dr. Shaw. He remained for nine months reverting to the Mysore Agricultural Department on the 1st April 1936.

Advisory Work:—A gratifying increased employment of the Department by Planters is demonstrated by a marked increase in correspondence, part of which has arisen from the wide spread interest in Composts.

Letters despatched increased to 1568, a 49 per cent increase over the preceding year; letters received to 1353, a 44 per cent increase.

96 letters were received, and 90 despatched in connection with the Quality of Coffee investigation.

Publications:—During the year 'Tea Manufacture in South India', a work written by Dr. Jones appeared in serial form in the *Planters' Chronicle* as indicated in last year's Annual Report. It commenced in the April issue, the concluding instalment appearing in December 1935. A foreword by Dr. Shaw, a Table of Contents, a short Appendix, a Subject Index and an Authors' Index have been added and the whole is being produced in book form, and will be available in May.

At the request of the Secretary, U. P. A. S. I., Dr. Shaw contributed a short article on 'Tea Waste as a Manure' to the *Planters' Chronicle* (July 27th 1935).

An article on Pink Disease has been written by the Mycologist, and it is hoped that this will be published during the coming year.

Pests and Diseases:—The year has not produced new attacks of disease of any importance, with the exception of a species of looper caterpillar, tentatively identified as *Ectropis bburmitra*, Warr. which gave cause for alarm on an Estate in South Travancore.

Touring:—No touring involving visits to estates was carried out during the year by the European Officers. The Entomologist proceeded to South Travancore (Ambanaad Estate) in October for a prolonged stay to investigate factors affecting *Helopeltis* in that District. His remarks are included in the Entomological section of this Report. He also paid visits to two other estates while in the District.

In November, the Chief Scientific Officer visited the High Range to supervise the Soil Chemist, proceeding from there to South Travancore to visit the Entomologist and arrange for spraying experiments on *Helopeltis*. He was able at the same time to address a meeting of members of the Central Travancore Planters' Association.

Appreciation of the renewed contact made during the short tour between Planters and a Scientific Officer has been mutually felt, and has encouraged an increase in the Budget allotment for touring in the coming year. Voluntary invitations to the Scientific Officers to attend meetings have been received, and an appreciative response is being made in May by Dr. Jones, who is attending meetings of the Central Travancore, South Travancore and Mundakayam Planters' Associations.

In January 1936, the Chief Scientific Officer proceeded to Calcutta with Mr. E. H. Francis in order to interview Professor F. L. Engledow.

During Dr. Jones' Home leave he was enabled to address members of the South Indian Association in London on the work of the Department. A precis of the address has been published in the *Planters' Chronicle* (21st March 1936).

Professor F. L. Engledow:—In 1935, the Indian Tea Association decided to form a Commission headed by Professor F. L. Engledow, for the purpose of enquiring into the constitution, administration and operation of the Tocklai Experimental Station, and also to examine the practicability of co-operation between the various Experimental Stations engaged in tea work. The U.P.A.S.I. Tea Scientific Sub-Committee recommended, and was supported by the Executive Committee and the South Indian Association in London, that steps should be taken to bring the South Indian Tea Scientific Station before the notice of this Commission.

For this purpose, the Chief Scientific Officer and E. H. Francis Esq., Executive Member for Tea, proceeded to Calcutta in January 1936 to interview Prof. Engledow. In the meantime, it was considered necessary that Prof. Engledow should possess a full survey of the history, activities, and publications of the Department. This survey was drawn up by the Chief Scientific Officer. In addition a note was drawn up by Mr. Francis which gave in condensed form the views of districts on the Tea Scientific Department. This information reached Prof. Engledow before the interviews.

Three interviews took place with Prof. Engledow, and one with the full Commission of Enquiry. A Joint Report by Mr. E. H. Francis and Dr. Shaw has been drawn up giving the impressions derived from these interviews, a Report approved by Prof. Engledow.

For the information of those interested, arrangements are being made to publish the following Reports in connection with Prof. Engledow's visit:—

1. Chief Scientific Officer's Memorandum on Tea Scientific Department.
2. Executive Committee Tea Member's Note.
3. Joint Report of E. H. Francis Esq., and Dr. Shaw.
4. Dr. Jones' Address to South Indian Association in London.

The last mentioned has already been published in the *Planters' Chronicle*, and will be included in the same form in the above publication with the exception of the last paragraph, which is being modified to convey better the meaning intended, and to remove any misconception which may arise on reading it.

Composts:—As indicated in the first paragraph, a Soil Chemist was engaged to work on the question of Composts. Owing to the prominence given to Composts, it was considered desirable that the Department's views should be given for the benefit of South Indian Tea Planters. The subject has been undertaken in detail by Dr. Jones, who has written the section of this Report on Composts. The analytical figures with few exceptions have been submitted by Mr. V. Jayaraman, the Soil Chemist.

Briefly, the Department has found no reason to depart from its original contention made in the Annual Report for 1928/1929, i.e., to incorporate green material *in situ* where it is considered necessary to apply humus on a large scale to tea soils. In some minor respects compost making on a small scale may be justified on tea estates such as the hygienic disposal of obnoxious material, and as a means of employing surplus labour to a small extent.

We wish to emphasise that the views expressed in the Compost Report are intended as a submission of views and not to decry the efforts of those Planters already actively engaged in making Composts.

Acknowledgements:—It is with pleasure that the following acknowledgements are made by the Officers of the Department:—Mr. A. P. D. Lodge, for arranging housing and facilities for the Entomologist on Ambanaad, for offering facilities when the Entoray Experiments were executed, and for his interest in the *Helopeltis* Spraying Experiments to be commenced in April; The Director, Imperial Institute of Entomology for identification of insects; The Director, Imperial Mycological Institute for identification; Dr. C. H. Gadd of the Ceylon Tea Research Institute and the Principal, Government Agricultural College, Coimbatore; The Kanan Devan Hills Produce Co., Ltd., for arranging Laboratory accommodation for the Soil Chemist, and to the Managers of Estates for hospitality received.

PLOT DETAILS

OLD TEA.

The past year has been favourable to high yields and the Old Tea gave its highest recorded yield. This is partly accounted for by the beneficial effects of the pruning treatment previously given, and because a proportion of the supplies have now become productive.

Month.	Green Leaf.		Made Tea/acre.	
	During month.	Total	During month	Total
April	525	525	44	44
May	484	1009	40	84
June	287	1296	24	108
July	1004	2300	84	192
August	915	3215	76	268
September	890	4104	74	342
October	1031	5135	86	428
November	682	5817	57	495
December	593	6410	49	534
January	537	6947	45	579
February	398	7345	33	612
March	501	7856	42	654

1926 PLOT.

This plot has also given a more satisfactory yield but as usual it was the first to be seriously affected by the dry weather and as a result it was pruned in March after the first showers had been received.

1926 PLOT YIELDS.

Pounds of Made Tea per Acre.

Month	Sub-Plot No.					
	1	2	3	4	5	6
April	21 $\frac{1}{2}$	21 $\frac{1}{2}$	6	3	6	11 $\frac{1}{2}$
May	48	44	46 $\frac{1}{2}$	46 $\frac{1}{2}$	51	36 $\frac{1}{2}$
June	12	13	8	4 $\frac{1}{2}$	6 $\frac{1}{2}$	10
July	50	48 $\frac{1}{2}$	50 $\frac{1}{2}$	54 $\frac{1}{2}$	54 $\frac{1}{2}$	36 $\frac{1}{2}$
August	75 $\frac{1}{2}$	93 $\frac{1}{2}$	98	90 $\frac{1}{2}$	80	52
September	48	52	58	56 $\frac{1}{2}$	60 $\frac{1}{2}$	37
October	59 $\frac{1}{2}$	74	67	75 $\frac{1}{2}$	66	42
November	71 $\frac{1}{2}$	72	73	81 $\frac{1}{2}$	74	44
December	49	54 $\frac{1}{2}$	47	54 $\frac{1}{2}$	39 $\frac{1}{2}$	26
January	42	41	45	38	28	23
February	15	22	31	22	14	21 $\frac{1}{2}$
March	4 $\frac{1}{2}$	4	10	7	10	20
Totals	497 $\frac{1}{2}$	521	550	534	490	360
Yield 1934/35 ..	424 $\frac{1}{2}$	495	422 $\frac{1}{2}$	397 $\frac{1}{2}$	306 $\frac{1}{2}$	257 $\frac{1}{2}$
1933/34 ..	153	125	146	197	105	89
1932/33 ..	292	345	199	88	70	94

1927 PLOT.

As before the yields were taken from 30 plots of 100 bushes each. The total crop amounts to 764 lbs. per acre, an increase of 106 lbs. per acre over the previous year. This plot will be pruned in April 1936.

Sub-Plot	Yields in lbs.	Green Leaf.	Total
	Half Section A	Half Section B	
1	120 $\frac{1}{2}$	118 $\frac{1}{2}$	239
2	106 $\frac{1}{2}$	105 $\frac{1}{2}$	212
3	121	97	218
4	102	83	185
5	157 $\frac{1}{2}$	49	206 $\frac{1}{2}$
6	126 $\frac{1}{2}$	95 $\frac{1}{2}$	222
7	142 $\frac{1}{2}$	77 $\frac{1}{2}$	220
8	183 $\frac{1}{2}$	90	273 $\frac{1}{2}$
9	154	108 $\frac{1}{2}$	262 $\frac{1}{2}$
10	152 $\frac{1}{2}$	117	269 $\frac{1}{2}$
11	113 $\frac{1}{2}$	100	213 $\frac{1}{2}$
12	99	97 $\frac{1}{2}$	196 $\frac{1}{2}$
13	98 $\frac{1}{2}$	80 $\frac{1}{2}$	179
14	111 $\frac{1}{2}$	100	211 $\frac{1}{2}$
15	131 $\frac{1}{2}$	107 $\frac{1}{2}$	239
Total ..	1920 $\frac{1}{2}$	1427	3347 $\frac{1}{2}$
Total 1934/1935	1649 $\frac{1}{2}$	1242	2891 $\frac{1}{2}$

1928 PLOTS.

The main block comprising Sub-plots 15 to 18 gave a yield equivalent to 1.078 lbs. made tea per acre. As this tea is only in its second year from pruning and is entirely without shade this yield is very encouraging.

Sub-Plot	Section	Green Leaf	Lbs. Made Tea Per Acre	Average of sub-plot in Made Tea per acre.
15 (Betjan)	{ 1	254½	995	1008
	2	285	1110	
	3	213	830	
	4	239	935	
	5	297	1160	
16 (Dangri)	{ 1	330	1290	1052
	2	201	785	
	3	223	870	
	4	276	1080	
	5	317	1240	
17 (Dhonjan)	{ 1	323	1260	1062
	2	231	900	
	3	248½	970	
	4	265	1035	
	5	293	1145	
18 (Nellimunda)	{ 1	316	1410	1200
	2	286½	1275	
	3	250	1115	
	4	227	1015	
	5	266½	1190	

Sub-Plots 19 and 21 which were originally high pruned, for comparison with Sub-Plots 20 and 22 which were low pruned, continue to yield slightly better results, the comparison now standing as follows:—

Year	Average yield of sub-plots 19 and 21	Average yield of sub-plots 20 and 22	Average yield of sub-plots 15 to 18
1930/31	.. 56	—	—
1931/32	.. 183	88	66
1932/33	.. 636	344	395
1933/34	.. 770	706	755
1934/35	.. 402	279	450
1935/36	.. 965	943	1078
	3,012	2,330	2,744

From the plots an interesting comparison can be found in the distribution of crop during the year for plots derived from Assam and from South Indian seed. Sub-Plots 15 and 19 are of Betjan, and Sub-Plots 18 and 22 are of Nellimunda.

Quarterly Distribution of Crop.

	April to June	July to Sept.	Oct. to Dec.	Jan. to March.
Assam ..	14.5%	36.1%	31.2%	18.2%
South Indian ..	17.2%	31.7%	28.5%	22.6%

Growth was slow during the first quarter as the rainfall was deficient following a severe drought. The second and third quarters were well suited to flushing but the last quarter was not such a serious drought as usual.

It will be observed that the South Indian Plot gave a more even distribution of crop.

1928 CONTOUR.

Sub-plots 23 to 26 were only plucked intermittently until the end of July in order to encourage a sturdy growth. Nevertheless the yields in terms of Made Tea per acre at the end of the year were satisfactory, being as follows:—Plot 23, 576 lbs., Plot 24, 321 lbs., Plot 25, 655 lbs., Plot 26, 592 lbs.

The extra supplies planted in June 1934 have been fairly successful and have become established in most places where they were chiefly desirable.

1929 PLOT.

This small area has again yielded remarkably well. The soil is somewhat gravelly and many of the bushes are of low jat but the following yields, expressed as lbs. Made Tea per acre have been obtained; Sub-Plot 27, 652 lbs., Sub-Plot 28, 1065 lbs., Sub-Plot 29, 1315 lbs., Sub-Plot 30, 905 lbs., Sub-Plot 31, 1105 lbs.

This area will be pruned in April 1936.

1930 PLOTS.

These have been in regular plucking since July 1935 but during April, May and June they were only intermittently plucked. Yields in terms of Made Tea per acre were as follows:—Plot 33, 465 lbs., Plot 34, 629 lbs., Plot 35, 719 lbs., Plot 36, 535 lbs., Plot 37, 470 lbs. These plots will be subdivided into small plots when next pruned.

METEOROLOGICAL.

The previous year, ending March 31st 1935 had been exceptionally dry. Shortage of rain continued during April and May and steady rains only began at the middle of June. The South West monsoon was very light and both August and September were characterised by frequent but light rain. October provided slightly more rain than usual but November was almost rainless. There were two small showers in December and no more rain until the early part of February when there were two storms which did much to alleviate the drought. More rain fell after the middle of March with the final result that though the annual rainfall was much below average the distribution of rainfall was, on the whole, good.

Month	Rainfall.	No. of days with Rain.	Average after-noon Max. Temperature.	Average Over-night Min. Temperature.	Humidity.		Vapour Pressure.		Cloud.	
					8-30 a.m.	3-0 p.m.	8-30 a.m.	3-0 p.m.	8-30 a.m.	3-0 p.m.
April ..	3.52	13	84.2	64.7	82.3	60.9	21.9	20.8	4.9	5.7
May ..	2.69	12	83.5	66.2	83.5	62.8	22.8	22.4	4.0	4.6
June ..	5.09	21	75.7	64.8	86.0	82.2	21.2	22.1	6.8	9.0
July ..	19.91	29	71.4	64.4	92.0	89.6	20.9	21.8	8.6	9.4
August ..	9.40	27	73.9	64.2	93.9	89.9	21.3	22.9	8.9	9.0
September ..	8.54	20	75.1	62.7	92.6	88.8	21.6	24.2	5.3	6.0
October ..	9.39	20	75.5	63.6	93.0	84.9	21.9	23.1	4.7	4.5
November ..	1.05	6	76.7	60.5	86.5	63.4	19.2	18.4	3.0	4.0
December ..	0.65	2	76.7	60.3	87.2	62.8	18.1	18.2	2.3	3.3
January ..	—	—	80.1	58.0	89.3	53.9	17.7	16.7	0.1	1.1
February ..	1.78	3	80.5	58.9	87.0	53.3	18.9	17.4	3.1	2.8
March ..	4.52	9	83.1	62.9	83.2	52.6	20.2	17.7	4.3	4.0
Total ..	66.54	162								

REPORT ON COMPOSTS.

INTRODUCTION.

During the past two years there has been a great revival of interest in the possibilities of composts in tea culture. The evaluation of the merits of composts has become somewhat controversial.

In this report an attempt has been made to sift the evidence affecting this question and to define the conditions under which composts may be of value to South Indian tea planters, and to emphasise the fact that in many cases their use is not economically profitable.

In order to set out the arguments affecting the compost controversy it is expedient to start with an account of the nitrogen cycle, to indicate the significance of the carbon-nitrogen ratio, and to outline the functions of humus in the soil. For this reason the early part of the report deals almost entirely with soil science preparatory to a discussion of composts themselves.

The study of composts naturally involves consideration of the allied subject of green manuring, and it is hoped that those planters who are interested in the latter will also find parts of this report helpful.

NITROGEN IN THE SOIL.

Nitrogen is one of the food materials necessary for plant growth. Plants absorb nitrogen through their roots. In the soil nitrogen can exist in a number of different forms of combination; as nitrate, nitrite, ammonia, or in proteins, amino-acids, and nitrogenous bases; or as free nitrogen.

Plants usually absorb their nitrogen in the form of nitrate. Some plants can assimilate ammonia but the circumstances under which this occurs have not been studied in such full detail. Tea can probably assimilate either but experimental evidence is lacking. Under certain conditions leguminous plants, by the agency of bacteria found in nodules on their roots, can assimilate free nitrogen.

THE NITROGEN CYCLE

In the soil the action of micro-organisms tends to break down the more complicated nitrogen combinations into ammonia which in turn is converted into nitrite and then into nitrate.

The nitrogen in appropriate form is absorbed by plants and converted into complex nitrogenous bodies. These usually revert to the soil when the plant dies and the cycle recommences.

There are however micro-organisms which have other influences on this simple rotation. Some evolve gaseous nitrogen instead of ammonia. These are known as denitrifiers. Others can convert free nitrogen into plant nitrogen; these are the *Bacillus radicola* found in leguminous nodules. Other bacteria can use gaseous nitrogen for their own metabolism; these are the *Azotobacter* which lead to nitrogen assimilation by an alternative process to that occurring where legumes are used.

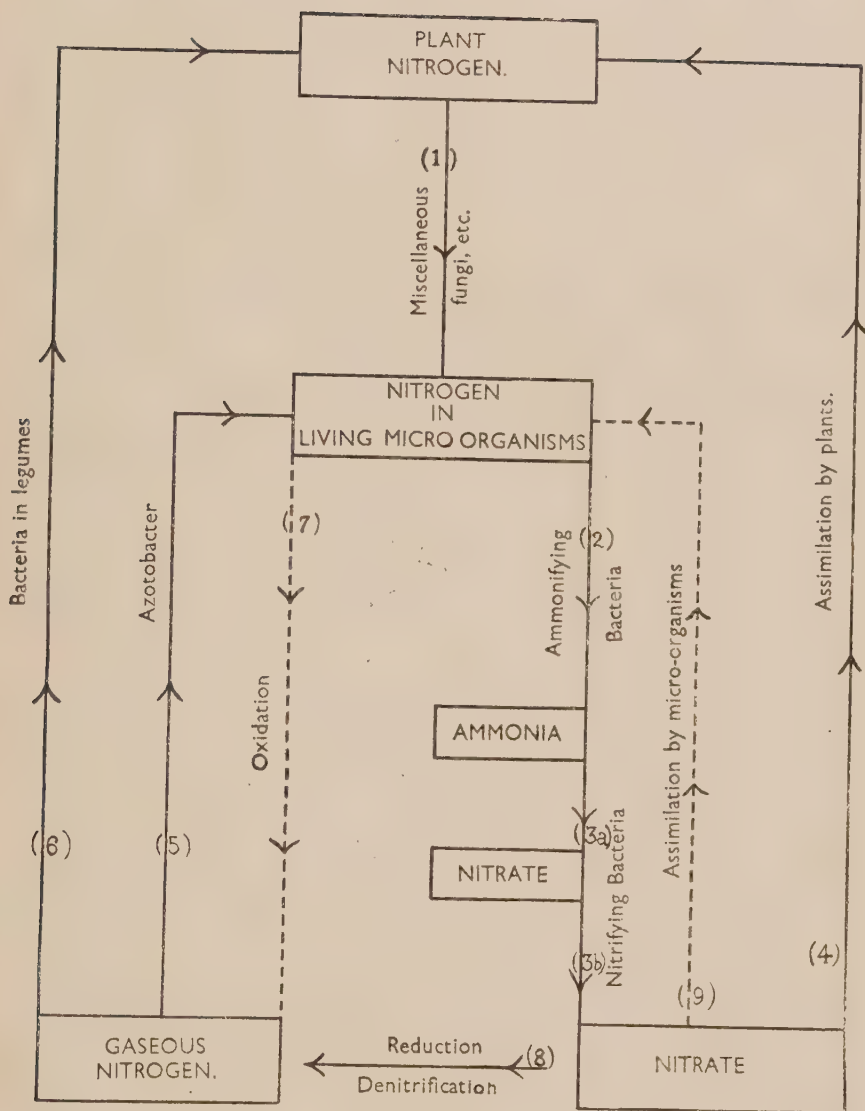
Finally the combined nitrogen may, besides being absorbed by plants, be lost in drainage water, reduced immediately to gaseous nitrogen, or be reabsorbed by micro-organisms.

These possibilities can be indicated diagrammatically as shown.

It is desirable to study the conditions which influence each type of activity which features in this circulation of nitrogen.

1. Plant nitrogen to micro-organism nitrogen by the action of fungi etc.

Organic matter incorporated with the soil is attacked by fungi and bacteria. The cell structure is broken down and much of the carbon is dissipated as carbon dioxide. The nitrogenous constituents of the organic matter are, for the most part, absorbed by the micro-organisms and converted into protoplasm.



————— Desirable channels
 - - - - - Undesirable channels.

2. *Micro-organism nitrogen to ammonia by the action of ammonifying bacteria etc.*

Many species of bacteria are known which can assimilate nitrogen in the form of proteins and amino-acids such as occur in protoplasm and these evolve ammonia as a by-product of their vital activity. Such bacteria can however exist on organic matter which is non-nitrogenous such as cellulose and carbohydrates, and where such matter greatly exceeds the amount of nitrogenous material there is a tendency for the production of ammonia to be seriously limited. Where the excess of carbohydrate is very great the production of ammonia may cease entirely and any existing ammonia be reabsorbed.

These ammonifying bacteria prefer a slightly alkaline reaction for maximum activity.

There are also certain species of fungi which are capable of liberating ammonia. These also are less active ammonifiers in the presence of an excess of carbohydrates. It is important to note that these fungi prefer an acid medium.

Some plants appear to be able to assimilate ammonia. Of these the best known are the trees growing on peaty forest soils. The position of tea in this respect does not appear to have been studied, although there are indirect arguments which can be applied to give some indication of the probabilities involved. These will be referred to later.

Ammonification proceeds most rapidly in soil with a water content of rather more than half its maximum water holding capacity.

3. *The Production of Nitrates from Ammonia by Nitrifying Bacteria.*

This operation occurs in two stages, the ammonia being changed first to nitrite by one type of bacteria, and the nitrite is changed to nitrate by a second type of bacteria.

The production of nitrite results in the liberation of acid in the soil, and unless this acid can be absorbed by soil bases such as calcium, the bacteria concerned diminish in activity. Under some circumstances, notably in the absence of calcium carbonate, mineral phosphates act as bases for the absorption of the nitrous acid and the availability of the phosphate itself is thereby increased as a secondary result. (Soil Conditions and Plant Growth—Russell).

The conversion of nitrite into nitrate appears to take place rapidly and as a result the accumulation of nitrite at no time becomes large. For all practical purposes the process proceeds in one stage, ammonia to nitrate. This does not affect the validity of the argument that the presence of bases is desirable.

Nitrification occurs best in a well aerated soil with a moisture content equal to rather more than half its maximum water holding capacity. The bacteria concerned probably function best at a temperature of between 90° and 100°F but are apt to be destroyed by exposure to strong sunlight.

Nitrifying bacteria do not thrive in the presence of a preponderance of organic matter. This has made culture work on them difficult and explains the absence of nitrate nitrogen in acid, forest soils.

4. *Assimilation of Nitrates by Plants.*

It has already been stated that the majority of plants depend entirely on nitrates for their nitrogen supply.

Nitrates are soluble and there is a strong tendency for them to be washed out of the soil before they can be utilised by plants. A wastage of nitrogen is therefore to be anticipated at this stage of the cycle.

The removal of nitrates by leaching, and the removal of a portion of the circulating nitrogen in the crop harvested, cause a diminution in the amount of nitrogen passing through the channels which have so far been discussed.

This unavoidable loss of nitrogen can normally be made good by the fixation of atmospheric nitrogen.

5. *Fixation of Atmospheric Nitrogen by Micro-organisms.*

Many species of bacteria to be found in soil are able to absorb atmospheric nitrogen for the continuance of their vital processes. Of these species one named *Azotobacter* has been most studied. Occasional fungi have some power of nitrogen fixation but up to the present no particular attention has been paid to these.

The *Azotobacter* flourish most freely in well aerated soils and in the presence of ample calcium and magnesium. It is generally concluded that a neutral or slightly alkaline soil is essential for their development.

These bacteria require the presence of carbohydrate matter in the soil and their activities are limited in the presence of an excess of nitrates. They prefer warmth in the soil but are more resistant to light and to desiccation than most other species. They also do best when the moisture content of the soil is rather more than half its maximum water retaining capacity. *Azotobacter* require the presence of phosphates and prefer mono- and di-calcic phosphate to other common sources. (Superphosphate is a mono-calcic phosphate). They can make some use of phosphates of iron and aluminium but apparently only with extreme difficulty.

6. *Fixation of Atmospheric Nitrogen by Leguminous Plants.*

Leguminous plants have a tendency to the formation of root nodules in which bacteria exist in symbiotic relationship to the host plant. The bacteria in the nodule fix gaseous nitrogen and the nodule thus becomes richer in nitrogen than the rest of the root. The final product is supposed to be a soluble protein which is passed on to the rest of the plant.

Legume bacteria are tolerant of acidity, and require an aerated soil. Nodule formation does not occur readily in the presence of nitrates, sulphates or ammonium salts, particularly if there is an excess of nitrate nitrogen. Nodules are encouraged by increasing the available potash and available phosphate.

Particular species of bacteria are associated with particular plants. Some species can exist in a soil independent of the existence of a host plant, but when introducing a new leguminous plant it is sometimes found necessary to inoculate the soil with earth in which an earlier crop of the particular plant has grown, in order that nodule formation can occur in future generations of that plant.

The gain in nitrogen by the soil depends on the incorporation of the plant with the soil. If the aerial portions of the plant are removed it is probable that no nett gain in nitrogen in the soil will be shown. Only by digging in the whole leguminous crop can an improvement in the quantity of soil nitrogen be attained. It has been stated that on a normally productive soil about two-thirds of the nitrogen content of a leguminous plant may be due to the fixation of atmospheric nitrogen.

It may be noted that in many tea soils the formation of nodules is frequently very limited.

7. *Oxidations.*

Under certain conditions which are as yet not fully understood losses of nitrogen occur which can only be attributed to direct oxidation. These occur mainly from very rich sources of nitrogen when the air supply is limited but not absent, but such losses may also take place as a result of intense heat in tropical regions of low rainfall.

8. *Denitrification.*

In the absence of adequate aeration nitrates in soils are attacked by denitrifying bacteria with the production either of nitrites, ammonia, or gaseous nitrogen. The bacteria concerned belong to definite species and the conditions governing their activity are well known. A plentiful supply of carbohydrate, a slightly alkaline medium and a waterlogged soil will cause the complete elimination of nitrate nitrogen.

9. *Assimilation of Nitrates and Ammonia by Micro-organisms.*

Despite the varied activities of bacteria previously recorded it is still true that most of the micro-organisms of the soil obtain their nitrogen by assimilating ammonia and or nitrate. Such nitrogen is not lost to the soil since it becomes available again as the organisms die, but it is not available to plants immediately.

The addition of raw organic matter to the soil causes an increase in microbial numbers. An immediate result of this is an increased demand on the ammonia and nitrate present with a temporary starvation of neighbouring plants. This effect is of importance where the remains of one annual crop are ploughed in prior to the planting of the following annual crop but is of less significance in the case of a perennial continuously cropping plant such as tea.

If the organic material added is also nitrogenous the nitrogen in it may be available in sufficient quantities for no withdrawal of pre-existing ammonia or nitrogen to take place. The critical point is in the neighbourhood of 1.8% of nitrogen in the organic matter.

If decomposed organic matter be added to the soil, as in the case of composts, no withdrawal of ammonia or nitrates should occur.

This absorption of nitrate and ammonia by micro-organisms is not wholly harmful as it may in some cases protect the nitrogen from loss by leaching. In India it appears that during the monsoon the increase of algae in the soil is responsible for avoiding loss of nitrates in this way.

THE NITROGEN CYCLE IN SOUTH INDIAN TEA SOILS.

From a study of the conditions affecting the stages of these nitrogen movements it is obvious that in tea soils in South India the nitrogen problem is of interest. The acidity of such soils and the shortage of calcium, magnesium, and available phosphoric acid would be expected to restrict movement in the nitrogen cycle almost to the point of cessation. It would appear that the nitrogen of plant residues would be absorbed by fungi and that certain ammonifying fungi could liberate ammonia from this source. The change from ammonia to nitrate must be relatively slow owing to the shortage of exchangeable bases. For the fixation of nitrogen the *Azotobacter* should be inhibited by the soil acidity, but fixations by bacteria other than the true *Azotobacter*, and by legumes would be possible to a limited extent. Nodule formation on the legumes might also be retarded to some extent by an accumulation of ammonium salts in the soil, a shortage of available phosphate and potash, and possibly by the absence of appropriate bacteria, particularly if the leguminous plants were not indigenous.

The influence of climate may also be considered. Most of the beneficial stages of the nitrogen cycle are favoured by a well aerated soil adequately supplied with water. It may be assumed that in tea soils the monsoon periods result in a loss of soluble nitrogen, the hindrance of the processes liberating it, with a slight tendency for some soluble nitrogen to be saved by reabsorption by micro-organisms. Draining would thus increase the supply of plant-available nitrogen and a cultivated soil would be preferred to an uncultivated soil.

During droughts bacterial activity would be hindered by lack of moisture in the soil, and there would be a tendency for direct losses of nitrogen by oxidation where the soil is exposed to the sun.

Conditions in South Indian tea soils would therefore tend to lead to the accumulation of non-available nitrogen. The total nitrogen could be increased by the use of leguminous green crops but this would not increase the available nitrogen.

It is possible that tea can absorb ammonia directly without undergoing the stages of nitrification. This is supported to some extent by the response given to sulphate of ammonia, even on acid soils containing a plentiful supply of organic matter, and by the fact that response to sulphate of ammonia is almost as rapid as that to nitrate of soda. The fact that tea responds to nitrate of soda tends to show that it is not entirely dependent on ammonia but can also utilise nitrate nitrogen.

THE CARBON-NITROGEN RATIO.

The Nitrogen cycle in soils shows the channels through which fluctuations in the form of nitrogen are effected. It is found that in soils the amount of nitrogen present is closely related to the content of organic matter. It is usual to find that in any soil in equilibrium the ratio of carbon to nitrogen is approximately 10 : 1. The existence of such an equilibrium is intimately related to the fact that most soil micro-organisms employ the destruction of carbonaceous material as a source of energy.

Where carbon is in excess of this ratio micro-organisms of the cellulose-decomposing type thrive and thus reduce the carbon content more rapidly than the nitrogen.

If the C/N ratio exceeds 12/1, nitrogen will not usually appear in the soil as nitrate and any ammonia or nitrate present is converted into protein. (Russell—*Soil Conditions and Plant Growth*).

If organic matter containing less than 1.8 per cent of nitrogen is added to a soil there will be a reduction in the nitrate content of that soil until the decomposition of the carbonaceous matter results in the percentage nitrogen reaching this point.

It appears from work by Joachim in Ceylon that the C/N ratio on tea soils of average acidity at Peradeniya is of the same order as in temperate countries. (*Trop. Agriculturist* January 1930). On the other hand, estimations of the Carbon/Nitrogen ratio in a number of South Indian soils showed an average value of 13.2. These soils however contained a number of samples taken because the growth of tea was poor.

It follows from the stability of the Carbon/Nitrogen ratio that in order to add nitrogen to the soil permanently it is also necessary to add carbon. Fertilisers

THEORETICAL ADVANTAGES OF COMPOSTS.

It is sometimes claimed that composts are more effective than green manures as a method of supplying the soil with humus and it is desirable to set out the reasons for these claims.

Well-made composts, when applied to soils, should add to the original soil a supply of decomposed organic matter, *i.e.* humus, nitrogen, a certain amount of phosphoric acid in organic combination, and potash.

Since the organic matter is in a rotted condition it should be possible for the ammonifying organisms to work on this material immediately and there should be no withdrawal of nitrate nitrogen from the soil and therefore no temporary starvation of any growing crop present. Herein lies the chief advantage of the use of composts over green manuring.

In their book 'The Waste Products of Agriculture', Howard and Wad lay great stress on the superiority of composts to green manures and deprecate the practice of green manuring. As their views are contrary to those usually voiced by tropical agriculturalists it is of interest to refer to them in some detail. They state that although green manuring has given satisfactory results on open soils where the rainfall is well distributed, and in rice soils where there is always an adequate supply of water, in the vast majority of cases the results have been disappointing. On monsoon fed areas the rainfall is often so uncertain that when sowing time arrives within eight weeks after ploughing in the green crop the soil contains a mass of partly rotted material with insufficient combined nitrogen and moisture for the growth of a crop. There is thus an important time factor which militates against the success of green manuring. In order to overcome this methods have been suggested for maintaining the necessary soil moisture by partial irrigation but these can only have a limited application. Howard and Wad quote experiments by Lohnis in which the same results were obtained whether the green crop was removed or whether it was ploughed in, and they therefore conclude that the double advantages of leguminous crops in (1) increasing the nitrogen supply and in stimulating the micro-organisms in the soil, and (2) of incorporating the green crop into the store of soil organic matter, can only be achieved 'provided full use of the crop itself can be found outside the field, either as fodder for animals, for making silage or as material for the manufacture of compost.'

This argument applies however to annual crops but not to tea. It is readily conceivable that the digging in of green manures may cause a temporary set back to crop but the final result should be beneficial since the slight modification of crop distribution is not necessarily harmful and there will finally be an increase in total crop.

The minimisation of the advantages of composts over green manures in the case of perennial crops has been emphasised by Eden (Tea Quarterly, July 1935 and Nov. 1936).

Phosphoric acid in organic combination is of importance in tea soils because it is likely to resist fixation by iron and alumina longer than inorganic phosphoric acid. This is possibly the greatest advantage of composts as applied to tea soils in South India.

The quantity of potash in composts is relatively high. Where there is a potash deficiency the use of composts might be valuable from this point of view but in South Indian tea soils there is no evidence that the large quantity of potash added by composts is of any special value.

The following figures indicate the supply of phosphoric acid and potash in the soils of some S. Indian Tea Districts.

	High Range	Anamal- lais	Nilgiris	Wynaad	Central Travan- core	South Travan- core
	%	%	%	%	%	%
Total Phosphate	0.13	0.13	0.12	0.11	0.11	0.10
Available Phosphate	0.013	0.012	0.009	0.004	0.007	0.004
Total Potash	0.30	0.38	0.15	0.15	0.29	0.23
Available Potash	0.018	0.016	0.010	0.010	0.019	0.019

THE INDORE PROCESS OF PRODUCING COMPOST.

The manufacture of compost is a biochemical process which requires careful regulation in order to achieve the most satisfactory results. A scientific study of the process has been made by many investigators, but Sir Albert Howard, late Director of the Institute of Plant Industry, Indore, has developed a practical method of applying these academic researches.

Comprehensive details, abstracted from 'The Waste Products of Agriculture', are given as briefly as possible.

PRELIMINARY ORGANISATION:

A compost factory should be near cattle sheds, a water supply and the source of raw material used.

The factory consists of a number of pits approximately 30 ft. by 14 ft. by 2 ft. deep. The depth is important.

During the monsoon heaps are preferred to pits.

COLLECTING RAW MATERIAL:

All vegetable wastes available are collected.

Woody material is crushed by being spread on roads having traffic.

Green materials are withered before storage.

Storing of materials should be done in layers about a foot thick.

Very hard materials should be stored separately, covered with earth and kept moist.

Silt from drains is stored near the cattle shed.

This earth is spread to a depth of 6 inches on the cattle shed floor and renewed every three or four months.

After being removed this earth should be crushed (in a mortar mill if available) and stored under cover as dry urine earth.

All wood ashes should be collected.

Wood ash and urine earth are as essential as plant residues.

CATTLE SHED WORK:

A quantity of the stacked vegetable refuse including about 5 per cent of hard material such as saw dust or waste paper is spread on the floor before the cattle are brought in.

During night this stuff becomes crushed and impregnated with urine.

such as ammonium sulphate do not add permanently to the nitrogen reserves of normal soil, but they might do so on soils with high Carbon/Nitrogen ratio. To improve nitrogen reserves organic matter must be added.

It has been pointed out that in South Indian tea soils natural conditions tend to the accumulation of nitrogen in the form of protein and the processes of nitrification and nitrogen fixation are both likely to be hampered seriously by the acidity of the soil.

One would therefore expect on an acid soil the accumulation of organic residues.

THE FUNCTION OF HUMUS IN THE SOIL.

Natural levels of organic matter and nitrogen in the soil tend to maintain themselves, approximately. Changes may occur if carbon and nitrogen are gained by the soil as a result of nitrogen fixation allied to the accumulation of leaf fall or other plant residues, in excess of anything removed in the form of a crop. Decreases in carbon and nitrogen are mainly due to the removal of crops to an extent greater than can be compensated by nitrogen fixation.

Thus the maintenance of nitrogen supplies in the soil are largely dependent on the presence of decomposed organic matter, i.e., humus.

But humus, besides regulating the nitrogen supply has other functions in the soil. It is not only a food supply for micro-organisms but it influences the tilth of the soil and its capacity for retaining water, and it also increases the retentive power of the soil for dissolved substances.

In tea soils in South India the amount of humus is variable according to district. The supply is generally good compared with that present in average tea soils in Assam or Ceylon, but in view of the desirability of maintaining crops during periods of drought it may be concluded that maintenance of the humus content is desirable.

A secondary influence of humus in tropical soils lies in its phosphorus content. This combined phosphorus is a source of available phosphoric acid as soluble phosphates are liberated by the action of micro-organisms. A high percentage of humus in the soil is also likely to decrease the fixation of phosphates by iron and aluminium. This is important in tea since the content of iron and aluminium in the soil is high. A reasonable amount of aeration is desirable in soils where the humus content tends to rise otherwise there is a danger of the formation of infertile peats. Excessive aeration on the other hand may lead to destructive oxidation of humus.

THE THEORY OF GREEN MANURING.

It is assumed that where it is desired to increase the humus content and nitrogen content of the soil this may be done by the incorporation of green crops.

If a leguminous green crop is grown *in situ* it is presumed that nitrogen is fixed by the bacteria in the nodules and that the soil plus the green crop therefore gains in nitrogen content. On digging in the green crop decomposition takes place resulting in the formation of new humus in which at least part of the nitrogen was derived from the air.

If a non-leguminous crop is grown *in situ* the nitrogen in it is derived from the soil, the withdrawal of this nitrogen ultimately causes a corresponding reduction in the carbonaceous content of the soil, and a fairly exact balance is again

reached when the crop is again decomposed in the soil. The nett result therefore, from these changes, is merely that a portion of the available nitrogen in the soil has been temporarily withdrawn from the soil. This procedure may result in an increase in the amount of available phosphoric acid in the soil since different plants absorb different forms of phosphate. The plant residues however contain all this phosphate in a more satisfactory form. Indirect benefits may accrue from this practice.

If the nitrogen is withdrawn from the soil into the non-leguminous crop at a time when the action of carbon-destroying micro-organisms are limited it seems probable that the carbon-nitrogen ratio in the soil might be slightly altered and that in due course a slight stimulation of nitrogen fixation in the soil might result. It is doubtful if this would compensate for the slight wastage of nitrogen due to the absence of theoretical precision in the decomposition of the green crop. At the same time it must be remembered that the nitrogen returned to the soil in the form of weeds is as available as that derived from leguminous plants. Moreover nitrogen absorbed from the soil by weed growth cannot be lost to the soil by leaching, and thereby the weeds serve some purpose as conservers of nitrogen.

The above arguments appear to show that the growth of weeds to be dug in cannot improve the total chemical richness of the soil appreciably and any benefit obtained is due either to increasing the availability of the plant foods or to the loosening of the soil.

If leguminous or non-leguminous organic matter is grown outside the tea and then carried in to the field, and dug in, an increase in organic matter and nitrogen is obtained.

If a leguminous crop is grown in the tea and the loppings obtained are removed in order to make compost no direct benefit accrues. If the compost is returned to the field the nitrogen taken away may be considered to have been replaced in a more available form but the operation is hardly economic.

Leguminous crops do not always produce nodules and if no nodules are formed no atmospheric nitrogen is fixed and therefore the crop adds nothing permanent to the humus or nitrogen content of the soil. Where nodules are present the amount of nitrogen fixed is approximately proportional to the extent of nodule formation. Moist soils are more fruitful than dry soils in this respect.

Green manures should not be buried during periods of drought as the water required to bring about their decomposition is drawn partly from the neighbouring soil and thus limits the amount of moisture available to the tea. The decomposition of green manures may be somewhat retarded during excessively wet weather owing to lack of aeration in the soil.

The amount of nitrogen fixed by the green crop is at a maximum just before flowering occurs.

It has been shown by experiment that nitrogen enrichment as a result of green manuring does take place in acid tropical soils although acidity is known to reduce the effectiveness of the legume bacteria.

As stated previously, where leguminous plants do not produce nodules it may be possible to stimulate their growth by inoculating the soil.

Experiments by Joachim showed that green manuring reduced the acidity of soil at Peradeniya.

as is shown by the complete disintegration into a smooth humus of all the leaves and plant fibres. If this is so take away a quarter from the third heap, pass it through a screen to remove stones and twigs and either store it in a heap or use it at once. Fill up the third heap with a quarter from the second heap as before.

If on the other hand the decomposition does not appear complete begin a fourth heap in the same way taking a quarter from the third to start it. It is seldom that more than four heaps will be required. When this stage is reached it should be possible at intervals of not more than a fortnight to take away a quarter from the fourth heap for use, fill up the fourth heap from the third, the third from the second, the second from the first and the first with raw material.

Throughout the fortnight all the heaps should be kept moist by sprinkling further additions of the solution on to the heaps. It will be found that as the heaps become more and more ripe less solution will be required to keep them moist as the material naturally retains more moisture so that the first heap will always require the most and the last heap the least, no heap must be allowed to become sodden.

In course of time it will probably be found that the fermentation becomes more active owing to the development of the organisms specially suited to the local conditions. It may then be possible to take away half of each heap at a time instead of a quarter.

It will be seen that the total area and volume of the heaps required will depend on the quantity of refuse to be dealt with. If larger heaps are required they may be lengthened, but should not be seriously increased in depth or width.

The time required to prepare the first heap or activator will naturally vary according to the character of the material dealt with, (whether soft, such as grass, weeds and soft leaves and stems of plants; or tough leaves such as mango, Java fig., etc.,) and the weather conditions, it may take less than a week, but should not exceed a month.

"The last heap should be ready in about 3 months from the start".

THE LINCOLN METHOD FOR THE MANUFACTURE OF COMPOST.

This method is useful during wet weather. Cattle shed floors are covered to a depth of about a foot with tightly packed earth. Cattle are bedded down each night with a supply of suitable withered green material. After three or four months the accumulated bedding and the saturated urine earth is removed.

The material so obtained forms a compost which is relatively rich in nitrogen, phosphate and potash but the C/N ratio tends to be high and the yield of compost per head of cattle is less. It is reported by Managers who have tried this method that the accumulation of bedding encourages the breeding of flies and other insects and is considered therefore insanitary.

COMPOST MAKING IN TEA DISTRICTS.

Estate operations necessarily sacrifice theoretical perfection in the interests of practical economy. In consequence the methods employed do not strictly follow the recommended procedures.

The Indore system appears to be the one most generally employed. The chief modifications introduced in practice appear to be,—

(1) Only a portion of the raw material is used as bedding. More withered green stuff etc. is mixed with the bedding when the pit is charged.

(2) The quantity of urine earth employed is considerably reduced.

(3) Watering is done regularly but not necessarily on the exact day recommended.

(4) The proportion of cattle manure employed is somewhat variable.

The results of these and other modifications are that the temperature does not rise as much as it should and the composting action is therefore slow. Heaped composts three months old are still quite hot but the disintegration of the material is still incomplete. In order to reduce such composts to their best theoretical consistency a longer time should be allowed for the decomposition to proceed. It is suggested that the process might with advantage be spread over 4 months instead of 3 if it is considered desirable to improve the quality of the compost.

The Indore pit system is inconvenient during the monsoon and if composting is continued heaps are made instead. Both the quality and the quantity of compost decline during the monsoon.

The Fowler system is in use on some estates and will probably be adopted by more estates in due course; The chief advantage of this method is that much less cattle manure is required and hence where control of cattle is difficult or where grazing grounds are limited this system is much more applicable.

The Fowler system is less mechanical than the Indore process in that no exact schedule has been laid down. As a result the final product is judged by its actual merits rather than by the theoretical expectation.

THE COST OF COMPOSTS.

The total cost of making and applying compost must be considered under three main heads.

- (a) Initial Outlay.
- (b) Cost of Manufacture.
- (c) Cost of Application.

INITIAL OUTLAY.

For economical working it is essential that the site of a compost farm must be well chosen so that the following conditions are satisfied as fully as possible:—

- (a) Proximity to cattle sheds where the greatest possible number of cattle can be congregated each night.
- (b) Proximity to an adequate and unfailing water supply.
- (c) Proximity to prolific sources of raw material other than the fields of tea.
- (d) Proximity to the tea so that the ultimate transport to the fields may be cheap.

It is probable that suitable cattle sheds do not exist at the point where the compost farm should be situated. In such cases it may be expedient to erect such sheds. This will contribute to the initial cost. Where sheds are already present they may have to be enlarged or modified or a lean to added for the storage of urine earth etc.

Usually a stream is to be found near the grazing grounds or jungle patches and this may be useful. Where a pipe line distribution to coolie lines exists it is probable that one of these can be tapped to provide laid-on water to the

In the morning fresh dung equivalent to about 5 lbs. per head of cattle is removed to the compost pit to be used as a component of a slurry. The remainder is well mixed with the bedding and urine earth at the rate of 5 lbs. per head of cattle is added. This is then removed to the compost pit. The cattle shed is then cleaned out and fresh earth and bedding laid.

CHARGING THE COMPOST PIT:

A slurry is made by mixing equal weights of wood ashes and urine earth, some fresh dung, some material from a pit 10 to 15 days old, and water. This serves to infect the material with appropriate fungi.

Bedding from the cattle shed is spread in the pit in a layer about 2 inches deep. The stirred slurry is sprinkled over this layer and the soaked residue from the slurry is distributed.

The next layer is similarly treated, more slurry being made as required.

When all the available bedding has been spread out, cattle shed sweepings are sprinkled over the surface and water is added. Further sprinkling with water is done in the evening and on the following morning.

The pit must be filled in 6 days or left incompletely full.

WATERING AND TURNING:

The maturing compost should be watered on the 12th, 24th, 38th, 45th, 67th and 75th days after the charging of the pit was begun.

The compost must be turned after 16 days, 32 days and 60 days.

The first turn consists of loosely piling the contents of one half of the pit on the top of the remaining half, adding at the same time water and portions of material from a pit of 30 days old to supply bacterial infection.

A second turn is given one month after charging, vertical slices being cut and then thrown loosely into the vacant half of the pit. The material is also watered at this stage.

A third turn coincides with the removal of the material from the pit to a heap outside the pit. The heap thus made should not exceed 10' x 9' x 3½' in dimensions. Water is added during this process.

The compost can if necessary be applied at this stage but it is said to be better to keep it in a heap for another month.

Water requirements for this process are large. It is said that 25 cart loads of compost per annum can be made per head of cattle, and 200 to 300 gallons of water are required per cart load of finished compost. 40 head of cattle producing 1000 cart loads of compost would thus require 250,000 gallons of water in a year.

The final product obtained at Indore is represented by the following analytical figures:—

Moisture		45	—	50%
Organic matter on Dry Wt.	„ .. .	19	—	22%
Wet „		10	—	11%
Nitrogen on Dry Wt.		0.8	—	1.0%
Wet „		0.4	—	0.5%
Insoluble ash on Dry Wt.		46	—	50%
Wet „		23	—	25%
Carbon Nitrogen Ratio		11	: 1	12 : 1

It is also possible to apply the Indore system to heaps if there is a danger of pits becoming flooded, but the results are not quite so good particularly if the heaps are exposed to wind.

There is a large rise in temperature during compost making by this method. The temperature should rise quickly to about 150°F and fall gradually to 85°F when the compost is mature. This heat kills insects and seeds and makes the process sanitary.

Features stressed by Howard as being of importance are the mixture of raw materials so as to obtain an original carbon nitrogen ratio of 33 : 1, the importance of wood ashes and urine earth, the necessity for good aeration, and the avoidance of factors likely to upset the temperature of the material, as, for instance, excessive watering.

ACTIVATED COMPOST ACCORDING TO FOWLER'S METHOD.

Another practical method of making compost was evolved by Fowler in an attempt to dispose of the sewage of Indian Municipalities, and modifications of this method can be utilised by planters.

"Collect any material such as weeds, grass, leaves (green and dry), and other garden and household rubbish including garbage and ashes. Out of the material form a heap about 6 feet long, 3 ft. wide at the base and 2 ft. high, chopping any long stalks into small bits.

Take a basketful, or a maund (28 lbs.), of fresh unmixed cow dung, and make it into a thin mixture with urine and water. Night soil might also be used with advantage instead of cow dung. A small quantity of bonemeal may be added with advantage.

With this solution moisten every portion of the heap thoroughly by sprinkling and stirring. Keep the heap moist from day to day until the temperature rises and then begins to fall decidedly and the material shows signs of disintegration and crumbles between fingers when handled. It is necessary to take the temperature of the material in the heap frequently. In Bangalore it rises up to about 50° to 70°C. The fermented material constitutes the "Starter" or "Activator".

At this stage remove a quarter of the heap of the Activator (the first heap), and pile it about a foot away from the first heap; this pile is the beginning of the second heap. Make up the first heap to its original size with fresh material. This fresh material should be thoroughly mixed with the rest of the first heap. How this can best be done is a matter for local convenience. Both the first heap and the first quarter of the second heap should be kept moist but not wet by further sprinkling with solution.

The temperature of the first heap will again rise. As it begins to drop remove a quarter of the heap again and mix it with the first quarter of the second heap which now becomes half the size of the first heap. Fill up the first heap as before with fresh material. Repeat these operations until the second heap equals the size of the first. The next operation will be to start a third heap by taking a quarter from the second heap, making up the second heap to its full size with a quarter from the first heap, which is again brought to its full size by a further addition of raw material. This process may be continued until the third heap is equal in size to the first and second heaps. It will be seen that fresh raw material is only added to the first heap.

It may be that by the time the third heap is complete and has been allowed a short period of final fermentation that the material will be ready for use,

It is interesting to consider how far these advantages are of economic value in South Indian tea soils. Poor growth of tea in S. India when due to soil conditions is usually attributed to,—

- (1) Lack of humus.
- (2) Non-availability of plant foods.
- (3) Lack of available phosphoric acid, or potash.

Lack of humus is associated with isolated gravelly patches where all growth is poor, such as frequently occur on hill tops; and on estates which have been poorly cultivated, have lacked shade and which suffer badly from drought. The conventional treatment of poor patches has consisted of trenching, green manuring and the application of cattle manure. It is not easy to produce rapid improvements on such soils but since cattle manure has not always been available in quantity the most practicable method has been to grow green manures, both on the patches and outside them, and to bring in this green stuff in trenches. Experience has shown that by careful work much good could thus be done at a relatively small expenditure.

The provision of large supplies of composts to such areas would do an immense amount of good and this method can probably compete, economically, with that of digging in green stuff, except where transport charges become exorbitant.

Where lack of humus has been a characteristic of an estate great improvements have been wrought by introducing shade trees, increasing cultivation and the employment of envelope forking. In such cases the addition of compost properly incorporated with the soil would be expected to enhance the results but it should not supplant the methods already in use and would therefore be an additional expenditure. Few estates of this type under present conditions can afford to increase their expenditure to this extent.

The application of composts in moderation according to the limits imposed by a careful study of cost per pound appears justifiable in these circumstances.

It is possible that much of the enthusiasm displayed in composts is due to the hope that composts will give results on tea comparable to those obtained on plain crops at Indore. It does not seem to be realised that average South Indian tea soils are incomparably richer in humus and nitrogen than the Indore soils.

NON-AVAILABILITY OF PLANT FOODS.

It is claimed in certain districts in South India that though the soils appear rich in humus, nitrogen, phosphoric acid and potash the yields obtained are not proportionate to the apparent richness of the soil and this is held to indicate that these plant requisites are not in an available form.

Tea appears to feed greedily on composts and therefore the application of compost should assist towards the maintenance of high yields, but there is no evidence whatever that such treatment does anything towards making use of the natural resources of the soil. There is a hypothesis that composts carry with them micro-organisms which are lacking in the soil and which will render available the natural supplies of plant foods. This idea is only a surmise, and is unsupported by any experimental data.

If the non-availability of plant foods is a fact, and this is not definitely established, it is probably due to a lack of appropriate micro-organic activity. This absence of activity must be attributed to some condition of the soil inhibiting the development of the required bacteria and fungi, and not to their absence by

some unfortunate mischance. Until the identity of this inhibiting factor is traced the attempt to remove it by the addition of composts can only be regarded as an experiment. Even supposing the missing micro-organisms exist in the compost there is no reason to suppose that they will be able to live and multiply in the soil.

Many rich but apparently infertile soils in South India can be classified as having a high C/N ratio and low acidity, or a low C/N ratio and a high acidity. A high C/N ratio suggests the presence of undecomposed organic matter. Without more detailed investigation it is not possible to state the reason for this but lack of aeration is tentatively suggested as the most common cause. The addition of composts will not help this, but cultivation will. A low C/N ratio and high acidity definitely suggest the suppression of nitrifying bacteria owing to the absence of an adequate supply of mineral bases. Here again composts cannot help appreciably but the addition of lime in small quantities or the application of heavy doses of phosphates might be serviceable. No general recommendation of such procedure would be sound unless based on an exact knowledge of the soil to which it would be applied.

It may therefore be concluded that the use of composts on soil in which plant food is present in large quantities but in an unavailable form does not benefit the soil but is merely a substitute for artificial manures. The humus content of the compost has no direct value, the amounts of nitrogen, phosphoric acid, and potash are ill-balanced and ill-defined and their relation to the actual requirements of the soil is indeterminate. Rational manuring should be able to produce equal effects at less cost.

It should be noted that the non-availability of plant food is only a hypothesis which may be incorrect. Other explanations can be advanced based on the possible existence of other limiting factors such as those of soil temperature, soil moisture, the presence of plant poisons or a shortage of other normal, though minor, soil constituents such as sulphur, boron, magnesium, available iron, or manganese. Laboratory researches are necessary in order to dispose of these.

Factors of other types also limit yields as, for instance, wide planting, fine plucking, unsuitable pruning, the absence of shade, and inadequate cultivation.

LACK OF AVAILABLE PHOSPHORIC ACID OR POTASH.

Judging by analyses, many South Indian soils are somewhat lacking in available phosphoric acid and more rarely in available potash. These plant foods are present in the green material and ashes employed for compost making, and in the cattle manure. Very little if any is lost during the manufacturing process and the product is therefore relatively rich in these mineral nutrients. The potash in decomposed plant residues is readily available to plants. The phosphoric acid is present in a combined form but the action of micro-organisms converts this into soluble phosphates quite readily. Consequently in soils where the supply of these is deficient the addition of composts will have some remedial effect. It must be remembered that this only applies to composts in which the raw material has been derived from waste land. No useful purpose under this head is served by removing from the tea fields the loppings and droppings of shade trees, weeds, green manures or prunings, but factory waste may profitably be returned to the fields in this form.

In soils where the only fault lies in a deficiency of available phosphate composts are not likely to be the cheapest and most efficient method of making good this shortage.

compost farm. This may involve a considerable initial outlay but where compost making on a large scale is meditated it is likely to be a remunerative proposition provided the water supply is adequate.

The cost of collecting material is likely to be reduced if the compost farm is near a road or roads where coolies pass daily on their way to or from their work, or which is frequently used by leaf carts or estate lorries. In general a site near the factory meets these requirements.

The cost of digging pits must be added where the Indore system is used. To dig a pit 30' x 14' x 2' and dispose of the soil excavated will usually cost Rs. 5 or more and this materially effects the cost per ton of the compost produced during the first year's work.

Figures kindly contributed by the Managers of estates suggest that the initial outlay is sufficient to increase the cost of compost making by about Rs. 1/8/- per ton calculated on the outturn for the first year.

These early expenses are of course justifiable where they contribute to cheaper production in subsequent years.

COST OF MANUFACTURE.

The chief items here are the cost of collecting suitable raw material and the cost of the work on the farm itself. The cost of collecting material and transporting it to the farm is likely to be prohibitive unless there is a large supply close to the farm, or unless the cost of transport can be greatly reduced by arranging loads for coolies, carts, or lorries, which would normally be passing near the compost farm unladen. It is quite feasible to arrange for coolies to cut and stack jungle growth and vegetable refuse at outlying points where they can be picked up by pruning coolies, weeding coolies, etc., on their way back to their lines or evening muster, and deposited in places from which they can be collected by empty leaf carts, empty firewood carts, or by other returning gangs of coolies for transport to or near the compost farm. By organising the collection of material from suitable areas at convenient times and by providing for temporary storage at strategic road junctions it is possible to tap distant sources of raw material at a low cost.

The success of economic compost making depends almost entirely on the extent to which the cost of collecting material can be reduced.

Variations in this cost from day to day make it impossible to define the actual expenditure to be expected under this head.

The cost of work on the farm is less liable to wide fluctuations. Probably 4 coolies can manage 10 Indore pits charged at the rate of one pit every six days, with a reduction in labour towards the end of the compost season when no fresh pits are being charged. The preparation of urine earth, collection of factory ash and other minor works would provide work during part of the time before the full battery of pits is working, at the beginning of the season.

Fluctuation in cost of the work on the farm will depend mainly on the number of pits being in a convenient ratio to the number of coolies constantly employed; on the availability of water; and on the availability of cattle manure. A pipe supply with taps and hoses can be operated very much more cheaply and efficiently than watering by hand.

Lower costs than this may be achieved only under exceptionally favourable circumstances or by taking liberties with the process. If economies are over-stressed it is likely that the product will suffer but within limits it is justifiable

to save labour on some details of procedure without significant loss of efficiency. The main function of urine earth for instance in the Indore process is as a base for micro-organisms and by reducing the quantities of this to some extent the quality of the compost suffers little although it may take slightly longer to reach maturity.

In order to carry out the Indore process cheaply and satisfactorily great attention to organisation is necessary. The Fowler process does not require as much forethought and preparation but with a well organised layout and a systematic timetable based on observation and experience it seems probable that composts could be made in this way a little cheaper than by the Indore method.

COST OF APPLICATION.

The chief items which regulate this are the cost of transport to the field and the extent to which the field is served by cart roads. No standard figure can be quoted for this work even for one estate as the cost will vary from one field to another.

In general the costs will be lower if the compost farm is conveniently situated, if estates are well roaded and where the area served by the farm is small.

The method of application has a slight effect on the cost. Broadcasting is cheap but to get the greatest benefit the material broadcasted must be dug into the soil. This part of the labour can usually be charged to cultivation. If it is considered more desirable to concentrate the compost in pits it is usually necessary to add the cost of making the pits, and of covering them in, to the cost of compost application.

TOTAL COST OF COMPOSTING:

Owing to the large effect of variations in conditions on individual estates it is difficult to determine with any certainty the normal total cost of composting.

Figures have been published by Howard, and by the Ceylon Tea Research Institute and from these it appears that the total cost of a 5-ton application per acre may vary from Rs. 12/8 to Rs. 44. In most South Indian tea districts the annual expenditure on composting is calculated at between Rs. 20 and Rs. 30 per acre. On a group of estates where the work was well organised and where natural conditions were favourable the total cost amounted to over Rs. 20 per acre but it was thought that this might possibly be reduced to Rs. 20 per acre by perfecting the organisation. In general if the cost is to be brought below Rs. 20 per acre it is impracticable to apply compost to fields other than those very near the compost farm. Apparently low total costs are sometimes attributable to false economies, as for instance, the collection of raw material from the tea fields, charging the collection of raw material to weeding or green manuring, making a very wet product or a very earthy one.

In order to get the best results from composting it is probably advisable to reckon the whole cost at Rs. 25 per acre if it is to be applied to fields in all parts of the estate.

THE VALUE OF COMPOSTS ON TEA SOILS IN SOUTH INDIA.

The orthodox view of the value of composts is that they contribute (a) humus and (b) nitrogen to soil. It is also claimed that since the carbon-nitrogen ratio is between 10 and 12 to 1 that the nitrogen is available for nitrification.

this effect can also be brought about in other ways which are likely to be less expensive.

SECONDARY ADVANTAGES OF COMPOSTS.

There are however other aspects of the situation which partially justify the making of composts on South Indian tea estates.

These may be listed as follows:—

(1) They afford a hygienic method for the disposal of material which might breed disease.

(2) Composts probably produce, temporarily, relatively small pockets of material with a p_H value more conducive to beneficial bacterial activity than the normal tea soil.

(3) Compost making may afford occupation for surplus labour.

The above points merit further discussion.

HYGIENE.

In making composts it is desirable to take steps to conserve all cattle manure and all line refuse. In the absence of any cogent incentive these frequently receive only perfunctory attention, and as a result they become sources of obnoxious smells, a breeding ground for flies, and a source of pathogenic organisms.

If used in the production of composts the microbic processes giving rise to bad smells are inhibited, the eggs and maggots of flies are killed and pathogenic bacteria are destroyed, mainly by reason of the high temperatures developed in the compost heap.

EFFECT OF COMPOSTS ON BACTERIAL ACTIVITY.

A discussion of the nitrogen cycle in soils demonstrated that the acidity of South Indian soils probably has a deterrent effect on certain types of bacterial activity which would be considered essential in non-tropical agriculture.

Composts are themselves slightly alkaline, mainly owing to the use of wood ashes.

As a result, as long as the compost retains its identity sufficiently to maintain its alkalinity there is a prospect of nitrification proceeding upon conventional lines, and it is conceivable that the nitrifying bacteria concerned may be able to deal to some slight extent with the sources of nitrogen originally existing in the soil. The economic importance of such a possibility can only be assumed after conducting research of an academic nature on the normal processes of nitrification in acid tea soils. Until it has been conclusively shown that lack of nitrification is a limiting factor governing the fertility of tea soils there is no proof that composts are of any significant assistance in this respect.

EMPLOYMENT OF SURPLUS LABOUR.

The recent labour conditions coupled with the necessity for stringent economy on estates have emphasised the problem of finding useful work for coolies during slack seasons. Under these circumstances compost making provides a means of employing labour, which is not devoid of profit.

The practicability of employing surplus labour in this way constitutes one of the most favourable of all arguments for the utilisation of composts in South

India tea. Composts can be made during the dry weather which is commonly the slack season, and provided that they are not stored too long, they can be applied at any time of the year when labour is available. It must be strongly emphasised that although it is very convenient to employ labour in this way this fact has no bearing on the cost of production or on the efficacy of composts.

THE INFLUENCE OF COMPOSTS ON THE COST OF PRODUCTION AND ON PROFITS:

It was stated by Howard in a paper read to the Royal Society of Arts in November 1935 that "the general introduction of the Indore method is certain to improve the fertility of the gardens and to lower the cost of production of tea".

The above statement cannot be accepted without qualification. The only way of reducing the cost of production of tea is to produce equal results at reduced costs or better results at an equal or greater cost. In times such as the present when crops are arbitrarily being restricted reduction of the cost of production can only be brought about by reducing expenditure. Consequently the use of composts can only reduce expenditure if the cost of making and applying compost replaces some more expensive measure without loss of efficiency. Composts can only be used to replace manuring or as a substitute for cultivation. On South Indian tea soils composts do not necessarily constitute an efficient or economical substitute for scientific manuring. Also, composts cannot possibly be a practicable substitute for an equivalent expenditure on cultivation, firstly because the cost of compost per acre is usually greater than the normal cost of cultivation, and secondly because cultivation has other useful functions which are unfulfilled by the use of composts.

Where restriction is inoperative increased yields may justify additional expenditure, and cause a lowering of the cost of production. Increased yields increase the expenditure on plucking, manufacture, packing and freight etc. The remaining estate charges can be expressed as costs per acre. If this residual cost per acre is increased by the total cost of adding compost the crop must increase proportionately in order to avoid any rise in cost of production. In general the improvement in crop must be between 50 and 100 lbs. in order to give cheaper production.

It is not necessary however to reduce the cost of production in order to obtain an enhanced profit. The smallest improvement in yield necessary to raise the profit per acre is approximately the figure obtained by dividing the cost of compost per acre by the ultimate profit per pound. The use of composts is therefore likely to pay where there is no need to restrict crop and where the profit per pound is large, but composts should be viewed with suspicion where profits are small, and avoided entirely where no increased crop is required.

RESULT OF ANALYSES OF COMPOSTS AND RAW MATERIALS.

Table I, appended, forms a summary of the analyses of composts carried out by the Department's Soil Chemist. Estates have been grouped in districts, and the number of composts from which the average analysis for each estate has been determined is given in parentheses. At the end of the table the average values derived from over a hundred other samples of compost which were only analysed with respect to their moisture content, nitrogen content and loss on ignition, have been included. All analyses have been expressed as a percentage of the undried compost and therefore they represent the value of the material in the form in which it would be applied in the field.

The average phosphate content of South Indian composts is about 0.22 per cent of the wet weight, and the potash content amounts to about 0.6 per cent. A 5-ton application would therefore include about 25 lbs. of phosphoric acid and 67 lbs. of potash. The amount of phosphate is low and the amount of potash excessive.

CONCLUSION ON THE VALUE OF COMPOSTS ON TEA SOILS IN S. INDIA.

In conclusion it may be adjudged from the foregoing arguments that the application of composts to South Indian soils is deemed worthy where there is a shortage of humus, provided that an expenditure of about Rs. 25 per acre can be justified by results which compare profitably with those obtained by cheaper or slower methods of supplying such a deficiency.

THE INFLUENCE OF COMPOSTS ON THE QUALITY OF TEA.

There is a tendency to believe that the addition of humus to a tea soil is likely to improve the quality of the made tea ultimately derived therefrom.

This feeling is based on the mistaken assumption that artificial manures cause a loss in quality in tea, and the idea that composts improve the quality of flowers and vegetables.

Two quotations from publications by Mann, who of all scientists has probably paid the greatest attention to the soil factors affecting the quality of tea, are worthy of note.

The first is taken from an article 'The Factors which Determine the Quality of Tea' reported in the *Tropical Agriculturist* for October 1907 p. 269.

The general consensus of opinion was such, as to lead in the early nineties (1890-1895) to the extensive opening out of tea gardens on the plateaux of South India, the whole of which lie at a level of 4,200 feet or over. The anticipation was that with a soil in which the tea plant is extremely luxuriant, with a jat or variety of plant which yields more easily and more copiously than the "China" or low hybrid common in Darjeeling, and with an elevation about corresponding to the best districts for flavour in India or Ceylon, a high flavour and a large yield were at the same time assured. So far this result has not been attained, and the tea, though giving a large yield, has not been of the quality which was expected. I will discuss later on why this is the case, but in the meantime it may be stated that the cause probably lies in the special character of the soil. This is, generally speaking, very light, and for such light soil very, or rather excessively, rich in organic nitrogenous matters. I shall show that excess of nitrogenous constituents in the soil always seems to lead to the production of luxuriance at the expense of flavour in the tea. But, if this is the case, time will afford a cure, and the Travancore plateau, if it does not produce the class of tea we associate with Darjeeling or the high gardens in Ceylon, yet is likely to give a flavoured tea at any rate at certain seasons of the year".

The second is taken from 'Tea Soils' published in 1935 p. 24-25.

"The present position of our knowledge is now almost the same as it was twenty years ago, and may be summarized as follows.

(1) High quality tea can only be produced when the amounts of organic matter and nitrogen are sufficient and within certain limits in relation to the reactive part of the soil. If these are present in too large amount, there is a tendency to give rank and abnormal growth of leaf and such rank growth is not likely to give high quality tea. On the other hand, if the proportion of

organic matter and nitrogen falls till it is no longer capable of maintaining a normal growth, then the quality of the tea falls off. The addition of any form of nitrogen that will maintain a continuously normal growth seems to be able to maintain the quality.

(2) If there is enough organic matter and nitrogen to maintain normal growth but not enough to produce rankness, then there is much evidence that the quality is affected largely by the amount of available phosphoric acid. If this has to be added to the soil, there is no evidence as yet, that one method of adding it is more effective than others.

(3) There is no evidence that large amounts of potash, either present in the original soil or added as a fertilizer, have very much effect on the quality of the tea produced.

(4) Excess of lime in tea soils will probably (though the proof is not complete) lead to a lowering of the quality of the tea produced, on account of its influence in giving non-luxuriant growth to the plants. The amount of lime added in any of the commercial manures (like basic slag) which may be used, would hardly be enough to give any injurious effect in a generation.

(5) The effect of the minor constituents of the soil, such as manganese and the lower oxide of iron, is not proved, and it is probable that most tea soils are well supplied with as much of these materials as they can use. A fuller study of the influence of the minor soil constituents on tea quality is, however, very much needed".

In the absence of any valid reason for disputing the acceptability of the latter conclusions it is fair to adopt them as a basis for computing the probable effects of compost manuring on the quality of South Indian teas.

Composts add organic matter, nitrogen and available phosphoric acid to the soil. The effect on quality should be beneficial on soils inadequately supplied with organic matter and nitrogen but lacking in available phosphoric acid.

Taking now the information available concerning South Indian soils the conclusion reached is that compost manuring is not likely to have any beneficial effects in the Kanan Devans, the Anamallais, or the majority of estates in the Nilgiris. Some estates in Central Travancore might be benefited, and the probability is increased in the Wynnaads and in South Travancore.

The benefit if any would be derived from the available phosphoric acid in the compost but there can be no guarantee that the effect on quality would be appreciable and similar results could be obtained merely by digging in weeds, green manures, loppings and leaf fall, or artificial manuring as all these would tend to increase temporarily the available phosphoric acid. In an annual crop this method of recirculating phosphoric acid might not be effective but in South Indian Tea which is cropping all through the year and where weeds, and shade trees are almost invariably present there is a constant exchange of phosphoric acid between the soil and the vegetation, and an almost constant amount being stored up in the vegetation. It is probable that plants draw to some extent on phosphates which are not very readily available and convert it into an organic, and more available, form.

Phosphoric acid as supplied by fertilisers is absorbed by plants and the tendency is for any phosphate applied in this way to swell the total of readily available phosphoric acid in an organic form.

The conclusion reached therefore is that composts may have a slight beneficial effect on quality where the soil is deficient in available phosphoric acid but that

MOISTURE CONTENT, LOSS ON IGNITION AND NITROGEN CONTENT.

It might be anticipated that a low moisture content would entail high values for loss of ignition, and nitrogen but in practice this does not appear to be true. The explanation of this apparent anomaly is that composts containing a high percentage of organic matter are capable of retaining large quantities of water. The moisture content of a compost by itself is therefore only significant when compared with the loss on ignition. If the moisture content is high and the loss on ignition is below average it suggests that the compost has been over watered, but if the loss on ignition is high and the moisture content low the compost is probably too dry.

The nitrogen content is the most efficient standard by which to judge the value of a compost. An average compost may be expected to contain a little less than 0.5 per cent of nitrogen and about 50 per cent water. Composts which are richer than this might be applied in smaller doses.

CARBON/NITROGEN RATIO.

It is significant that the carbon/nitrogen ratio is usually greater than 13. This indicates that the usual compost has not matured fully in the appointed time. It does not follow that the compost is well matured when the carbon/nitrogen ratio is low since this may be due to the use of highly nitrogenous raw material, but in this case the nitrogen content would probably be high.

In tea the final stages of ripening can take place in the soil without detriment. Since one of the aims of compost manufacture is to produce material with a low carbon/nitrogen ratio it must be concluded that if the ratio has not been brought down to below 15, much of the labour spent at the compost farm has probably been wasted.

PHOSPHATE AND POTASH.

The percentage phosphate commonly varies between 0.15 per cent and 0.50 per cent. It is usual to find that the variation between different composts of the same estate is very much less than this.

Potash is more variable than the phosphate but where a number of samples have been received from an estate with an established system of compost manufacture it is usually found that the analyses are within the same range. The amount of wood ash, and the amount of cattle manure probably have a large influence on the ultimate phosphate and potash contents.

GENERAL.

When a steady routine of manufacture has been established and the product is found to be satisfactory, it should be possible for the Manager of the estate to decide whether the standard is being maintained by inspection of the finished compost and detailed analyses give him very little additional, useful information.

RAW MATERIALS.

Table II includes analytical figures, relating to possible raw materials for composts, which have accumulated during the normal work of the Department in recent years. The analyses are incomplete since they were not carried out with a view to assessing their usefulness as raw material, but they may be of interest. One point which is worthy of note is the distribution of nitrogen in the leaves and stems of greenmanures. The leaves are very rich in nitrogen but the inclusion of stems reduces the average nitrogen content of the whole plant.

Grevillea leaves, containing only one per cent of nitrogen must be classified as resistant material. When these are used in composts they are usually among the last components to lose their identity. These leaves are completely disintegrated when they are incorporated with the soil either as constituents of composts or by envelope forking. As *Grevillea* droppings are usually derived from tea fields their presence in composts is usually a sign of false economy.

TABLE I.

Estate	% Moisture	% Loss on Ignition	% Nitrogen	C/N. Ratio	% Phosphate	% Potash
Central Travancore :—						
1. (1) ..	29.7	17.5	0.37	14.6	0.56	0.83
2. (6) ..	21.6	19.5	0.58	13.9	0.28	0.39
3. (6) ..	50.2	12.9	0.33	13.0	0.14	0.24
4. (5) ..	43.4	18.9	0.64	11.9	0.40	0.77
5. (1) ..	43.6	17.3	0.54	12.4	0.28	0.49
6. (1) ..	42.8	13.1	0.34	17.7	0.31	0.31
7. (2) ..	50.7	15.6	0.53	12.9	0.20	0.77
Kanan Devans :—						
1. (9) ..	53.9	14.2	0.47	14.2	0.28	0.61
2. (10) ..	66.4	12.9	0.42	13.2	0.19	0.38
3. (1) ..	55.4	10.6	0.39	11.5	0.27	0.50
4. (1) ..	74.0	14.7	0.56	17.0	0.15	0.45
5. (2) ..	57.5	18.4	0.58	14.8	0.30	0.87
6. (1) ..	62.3	13.8	0.49	11.6	0.25	0.46
7. (2) ..	67.4	11.3	0.38	12.2	0.20	0.83
8. (1) ..	52.1	14.0	0.48	11.7	0.24	0.45
9. (7) ..	64.4	13.9	0.49	13.1	0.36	0.89
10. (25) ..	62.6	16.0	0.45	15.5	0.23	0.73
11. (1) ..	62.1	13.0	0.39	15.1	0.23	0.65
12. (1) ..	46.3	14.6	0.43	13.5	0.20	0.89
13. (1) ..	71.0	11.6	0.37	15.0	0.16	0.62
14. (1) ..	28.2	15.6	0.50	13.0	0.35	1.30
15. (1) ..	63.0	15.4	0.38	15.5	0.24	0.33
16. (1) ..	65.9	15.9	0.47	12.1	0.17	0.33
17. (4) ..	62.0	15.0	0.45	16.6	0.21	1.02
18. (11) ..	67.1	15.4	0.53	14.1	0.22	0.50
19. (2) ..	62.8	23.8	1.08	11.2	0.23	0.22
20. (2) ..	67.9	15.0	0.48	14.8	0.17	0.69
21. (2) ..	30.2	16.1	0.50	14.1	0.36	0.97
Nilgiri Wynaad :—						
1. (11) ..	34.6	21.0	0.75	11.3	0.35	1.11
2. (1) ..	51.4	12.6	0.37	12.7	0.34	0.48

TABLE I.—(Contd.)

Estate		% Moisture	% Loss on Ignition	% Nitrogen	C/N Ratio	% Phosphate	% Potash
Wynaad :—							
1. (24)	..	43.5	14.4	0.48	12.9	0.23	0.89
2. (17)	..	42.2	13.0	0.44	12.9	0.24	0.53
3. (15)	..	39.7	15.7	0.46	13.4	0.22	0.55
4. (8)	..	37.6	17.8	0.53	13.3	0.39	0.77
5. (17)	..	45.9	14.5	0.46	13.6	0.20	0.45
Other Districts :							
1. (5)	..	42.5	16.1	0.56	12.5	0.29	0.58
2. (1)	..	12.1	25.9	0.68	18.1	0.12	0.40
3. (1)	..	54.7	11.8	0.30	15.0	0.11	0.22
4. (3)	..	43.1	13.1	0.31	15.1	0.19	0.47
5. (4)	..	46.2	15.5	0.49	9.9	0.28	0.72
6. (3)	..	30.3	20.0	0.62	13.3	0.37	0.72
Average of (218)	..	48.0	15.6	0.49	13.2	0.26	0.61
Average of (108)	..	40.3	13.1	0.47	..	..	..

TABLE II.

Material	Moisture	% Loss on Ignition		% Nitrogen	
		Wet Wt.	Dry Wt.	Wet Wt.	Dry Wt.
Cattle Manure ..	75.6	20.9	85.5	0.24	1.00
Urine Earth ..	50.3	17.5	35.1	0.20	0.40
Tea Fluff ..	8.25	82.5	90.0	2.55	2.75
Cassia laevigata :—					
Top wood ..	..	..	97.2	..	0.80
Middle wood ..	..	..	98.0	..	0.64
Lower wood ..	..	..	97.4	..	0.49
Tea :—					
Top wood ..	..	..	97.4	..	1.05
Middle wood ..	..	..	98.6	..	0.77
Lower wood ..	..	..	98.5	..	0.60
Dried grass ..	8.0	81.5	88.8	0.46	0.50
Grevillea leaf ..	..	..	..	..	1.00
Kooga leaf ..	..	..	..	..	2.60
Mugwort ..	12.5	79.0	90.4	3.16	3.61
Cassia hirsuta :—					
Leaves ..	72.4	25.2	91.3	0.98	3.53
Upper stem ..	67.7	..	..	0.46	1.42
Lower stem ..	55.2	..	..	0.39	0.86
Crotalaria Muij- uici :—					
Leaves ..	73.4	25.1	94.5	1.07	4.02
Upper stem ..	71.2	..	..	0.29	1.00
Lower stem ..	60.0	..	..	0.17	0.44
Crotalaria semper- flore :—					
Leaves ...	75.0	..	..	1.05	4.20
Upper stem ..	70.4	..	..	0.53	1.78
Lower stem ..	58.9	..	..	0.35	0.85
Sesbania Egyptica:					
Leaves ..	74.0	..	..	0.91	3.50

REPORT OF THE ENTOMOLOGIST.

ADVISORY.

The number of enquiries received during the year was 47 and in the majority of cases was accompanied by either the actual insects, or specimens indicating the nature of the damage caused. Termites, bark-eating borers, nettlegrubs, looper caterpillars and scale insects were prominent tea pests, while thrips, weevils (*Mylocerus subfasciatus*, Guer), borers and faggot-worms were reported as causing more or less serious damage to *Cardamoms*, *Acacia*, *Grevillea* and *Albizzia* respectively.

TEA.

Helopeltis. This problem occupied attention from the end of October to the beginning of January. The general conditions of infestation and the various factors influencing the attacks of the pest in South Travancore were studied, whilst a few points were also investigated with a bearing on its life-history. In the main, the behaviour of the pest does not seem to differ materially from what has been observed in Central Travancore.

In view of the contemplated spraying experiments, preliminary comparative tests were made with the three kinds of soaps, viz. Fish-oil-Resin soap, Hongay-oil-Resin soap and Groundnut-oil soap and two proprietary products, Nictagral C and Niconone. 1% strength of Nictagral C and 0.5% strength of Niconone gave effective kills in the laboratory but the cost of these products was too high for practical application. Accordingly arrangements have been made to utilise one of the soaps for the field scale spraying.

Entoray:—A demonstration of this machine was conducted in S. Travancore, chiefly with a view to determine its capability of attracting *Helopeltis*. Only one trial could be arranged and though negative, the merits of the machine could not be fairly judged on the results of this single attempt. The inventor, however, is making a more extended trial in Assam during the height of the *Helopeltis* season and the results will be closely watched.

Nettle-grubs:—No serious outbreak of this pest was reported during the year, but during the visits paid to various estates, their presence was invariably noticed. Since only the older leaves are attacked by the Nettle-grubs in mild infestations, their presence is considered unimportant, but it must be made clear that these nettle-grubs, of which a large number of species is represented in S. India, are capable of multiplying rapidly without warning when conditions are favourable. Every effort must therefore be made to check these pests wherever seen. Cocoon collection should form part of the estate routine, and a system of paying a cash bonus for the collection of those found on the leaves and in the soil beneath the bush should greatly assist in keeping the pest within control.

A further species of *Thosea* has been discovered in S. Travancore, but its correct identification is still engaging attention. This brings our list of Tea nettle-grubs to twelve.

Parasites sometimes play a very great part in keeping the nettle-grubs under control, and fortunately their activities are also often assisted by the prevalence of disease and predators. To the several parasites already reported in previous years, may be added another four, viz., *Buysmannia* sp. (Ichneumonidae) and *Goryphus* sp. (Ichneumonidae) attacking *Spatulifibria grisea*; *Enplectrus* sp. (Enlophidae) attacking *Narosa conspersa*; and *Fornicia Ceylonica* (Braconidae) attacking *Thosea cervina*. There are still a few un-named parasites whose identifications are being determined.

The disease affecting nettle-grubs mentioned above is probably analogous to 'Wilt' so common in Ceylon, but its exact nature is still under investigation.

Canthecona furcellata, wolff., is a common predator of *Thosea cervina* in S. Travancore. Both the adult bugs and the nymphs prey on the grubs, and in the case of the latter 4 to 6 of them may often be seen holding the grub at the end of their rostra and sucking the juice from the body of the grub.

Cordyceps pruinosa, a fungus reported previously as attacking the cocoons of *Thosea cervina* in Central Travancore and Mundakayam, is also prevalent in South Travancore.

Termites:—Depredations by termites have so far been exclusively confined to the Anamallais, and the hitherto controversial question as to whether they attack living tea bushes in S. India may now be taken as practically settled. It was previously indicated that *Coptotermes* sp. is capable of attacking tea in that district (vide *Planters' Chronicle*, 9th February 1935, pp. 55-56) and from further evidence obtained during the year, it has been found that another species, viz., *Calotermes* (*Glyptotermes*) is also involved in the depredation. The latter does not correspond to any of the three species of the genus *Calotermes* known to attack living tea in Ceylon but resembles most closely *C. (Glyptotermes) dilatatus*, being only slightly smaller. On forwarding the material to the Imperial Institute of Entomology, London, the insect has been identified as a new species of *Calotermes* for which a name has yet to be given.

Extensive work has been done in Ceylon where the termite represents one of the most formidable pests of tea. The result, so far as the aspect of control is concerned, has been to recommend the application of Paris Green during pruning time in the case of *Calotermes* spp. as these nest in the tea bush itself and can therefore be dealt with satisfactorily. Further it is said that this foreign matter is at once consumed by the termites, which immediately die, their dead bodies being promptly devoured by their fellows which in turn die, one lethal dose apparently persisting in this manner through an indefinite number of bodies until the entire colony has been exterminated. With regard to *Coptotermes*, however, the nest is not easy to locate as it may be in the soil far removed from the bush on which they are actually seen, and the application therefore of Paris Green, apart from killing the inmates of the gallery that may come in contact with the poison, will have no effect on the rest of the colony. Convincing practical and economical methods of destroying the central nest still remain to be investigated. Measures, preventive rather than remedial, have to be resorted to, and as this species of termite may also attack the bush above ground level during the colonising flight, steps should be taken to limit the number of pruning snags and to remove stumps of dead trees, as both of these afford points of entries into the tea bush.

Tea Aphis:—(*Toxoptera aurantii*, Boyer.) The position with regard to this pest remains more or less unchanged, although its depredation is mainly confined to nurseries and to tea coming in from pruning. Three reports of Aphid damage were received during the year, one to young tea, one to tea coming in from pruning and the third to nursery plants. Climatic conditions and the prevalence of parasites and predators exert a marked influence on the multiplication of this pest. A Coccinellid (*Chilomenes 6-maculata*), 3 species of syrphids (*Paragus atratus*, de Meij, *Paragus serratus*, F. and *Syrphus aldigatus*, Wied.) and an un-identified Hemerobiid prey of the Aphids, while a tiny Aphidiid wasp (*Trioxys* sp.) is parasitic on them.

Nicotine compounds appear to have a great toxic effect on these insects. Trials with Nicotine sulphate have already been reported in the Annual Report for 1933-34. During the year under report, Nictagral C, a proprietary insecticide supplied by the Imperial Chemical Industries Ltd. was also tried against it with very good results. 0.25% was sufficient to give uniformly high mortality in laboratory tests but, for general adoption as a suitable insecticide for tea Aphids, it would be necessary to determine how far this product compares, in point of cost, with the bazaar tobacco decoction with which successful results have also been obtained.

Trials with hot water extract of tobacco dust has already been mentioned in the advisory part of the report.

Shot-hole Borer:—(*Xyleborus fornicatus*, Eich.). This insect, recognised as one of the most pernicious pests of tea in Ceylon, has so far not attracted any great attention in South India. In fact, on going through the literature extant on the subject, one would find that the occurrence of Shot-hole Borer in India was in a controversial stage until recently. In 1918, Speyer, writing about the distribution of the pest, consulted both the North-east and South Indian authorities, from whom he concluded that "the authorities in India have recorded this insect in that country on the slenderest ground, and the fact that no specimens of *Xyleborus fornicatus* are available from India for identification, except in the one authentic case from Bangalore in Castor-oil tree, gives legitimate cause for assuming that the insect does not exist in tea either in India or Assam".

Subsequently, however, Beeson in 1926 pointed out that the above statement by Speyer was erroneous and in support of his contention published a record of all the localities in India from which *X. fornicatus* was collected. This record included Bengal (*Chittagong*) and United Provinces (Dehra Dun) in N. E. India and several localities in the Nilgiris in the south. In none of these localities, however, it was found on tea, and Beeson in his publications of 1930, stated that "there is no authentic record of the species from tea in S. India, the Dehra Dun district or Assam and Bengal, although it actually occurs in some tea-growing districts".

To the South Indian tea planter, this might have been a very re-assuring statement, especially after those made by Anstead and included by Fletcher in his "Some South Indian Insects", but an identification received from the Imperial Institute of Entomology of borers obtained in Central Travancore and stated by him to be *Xyleborus fornicatus*, leaves no doubt whatever that the insect is actually present on tea in South India. However, its occurrence has been reported from one tea estate only, and no other estate of the district has subsequently reported it. This may allay anxiety to some extent, but at the same time, it is also probable that its presence may be due to the fact that the insect has not appeared in numbers sufficient to attract attention. Having determined that it does occur on tea in Central Travancore, and realising that once the insect has established itself, it may be very difficult or even impossible to keep it under control, these estates should make every effort to eliminate risk. It is highly desirable that any suspicious borer of this genus found attacking tea, should be reported, together with specimens to the Tea Experimental Station, where attempts will be made to secure a correct identification.

THE TWIG CATERPILLAR:—

Depredation:—An outbreak of this pest, tentatively identified as *Ectropis bhurmitra*, Warr., occurred in such an epidemic form on an estate in South Travancore that bushes were stripped completely bare over more than a hundred

acres and the depredation had extended to about 350 acres. It was of an almost unprecedented severity in South India and affords a striking example of what an apparently insignificant insect, like a looper caterpillar occurring practically in every South Indian tea district, is capable of doing at times.

During the period of its activity which appeared to have commenced in October and continued with increasing severity till about December, it was stated to have been impossible for any one to pass through the affected fields without collecting hundreds of these caterpillars on the body and clothes. The fields were said to be swarming with them to such an extent that daily collections filled two to three 40 gallon drums.

The older leaves were the first to be attacked by the caterpillars and when these were exhausted, the younger ones next received attention. In a severe attack no vestige of green leaf would be left anywhere on the bush, and ultimately even the bark was attacked. Should one stand near while a severe attack is in progress, the caterpillars can be heard feeding.

Life-history.—The eggs are laid in crevices of the bark on the trunks of *Grevillea*, Rubber, *Gliricidia* and probably on any kind of tree in the affected area. The moths may also be observed resting on tea trunks, but it is doubtful if eggs are laid on them. The eggs are light green in colour, spherical or slightly oval in shape and are laid in a mass covered by a brown fluff. As many as 425 eggs in one mass have been counted. Presumably, more than one egg-mass is laid by individual female moths.

Soon after hatching from the eggs, the larvae commonly known as loopers, suspend themselves by silken threads and a gentle breeze is sufficient to transfer them to the surrounding tea. They are blackish just after emergence from the egg, but after the next moult assume a brownish colouration and during the succeeding moults their protective resemblance to tea stalks becomes very striking. The full grown caterpillar has a ground colour of brown with black marking of various shades on the dorsal surface. Two ear-like knobs are situated on the first thoracic segment. At about a third of length of body from its head appear two yellow patches and two lateral dots near the anal region are conspicuous. The caterpillars attain a size of two to two and a half inches in length. They devour the lower leaves on the bush first, then gradually work upwards until they consume even the flush, leaving nothing but hard stalks on the bush.

The pupa is formed just below the surface of the ground at the base of the tea bush. It is of a reddish brown colour, smooth and glossy.

The moth is very pale brown, speckled and spotted with darker markings which form wavy lines across the wings. They have an average wing expanse of $1\frac{3}{4}$ " to 2", but vary within very wide limits. The moths are sluggish and rest during the day flattened against *Grevillea* trunks, with wings expanded, their colour harmonising remarkably with the environment.

Seasonal History.—In both the years in which the pest broke out in epidemic form, its presence was first noticed during October—November, which leads one to think that it is pre-eminently a dry weather pest. The maximum damage is done from October—November to end of January, although caterpillars may be found as late as April. The seasonal history of the pest is not in conformity with its confrere in N. E. India or Ceylon.

What becomes of the insect during the period when it is not on tea is not yet known. It is possible that the pupae may hibernate in the soil or that the eggs laid in March—April may remain dormant till the following October.

The number of generations has not been definitely determined up to the present. It is probable that there may be 3 or 4 broods in a year, with two broods only occurring in a virulent form. Overlapping of generations occurs.

Other Host-plants:—*Grevilleas* and *Gliricidias* are the two other host plants on which the caterpillars feed, but the former appears to be preferred judging by the greater damage done to them generally. Rubber trees although favoured for oviposition were not attacked.

Control:—The fact that the pest also attacks full grown *Grevilleas* and *Gliricidias* will make it difficult to stamp it out without sacrificing such trees. The spread of the pest is not due to an actual migration of the caterpillars, but to the fact that the moths move onwards and lay their eggs where there is food for the future larvae. Since it is observed that the pest started in both years from the same locality, it should be possible to check the ravages and spread of the pest by the timely adoption of the necessary control measures. How far the various stages of the pest are amenable to treatment is outlined below.

The eggs, as already stated, are laid on *Grevilleas*, Rubber and *Gliricidias*. As the moths rest on these trees as high as 20 feet or more, the removal of eggs by hand cannot be efficiently carried out. Further, it would mean stripping the bark of such trees in search of egg-masses, which is impracticable. Application of a suitable insecticide to the trunks of trees can at present be considered of only doubtful value. It may deal with a large number of eggs and, no doubt, ward off future oviposition; but the cost of treating every tree and the expense of the labour entailed would be prohibitive. Even then, many eggs may hatch out, and the caterpillars that emerge are easily blown about by wind, and by means of silken threads may settle on the surrounding tea.

Collection and destruction of caterpillars in the very early stages may be attended with success, but is difficult practically in view of their inconspicuous nature and capacity for rapid increase. Very often, this measure becomes useless, and especially so, when the outbreak has taken a severe turn. In spite of the destruction of several millions of caterpillars, there will be many more still, and these successfully pupate and give rise to moths which start a fresh generation of the pest. After the pest has assumed an epidemic form, therefore, this measure would be of no avail whatsoever.

Spraying with a stomach poison is doubtless a very useful remedy, but in view of the possible taint it may give to the leaves, every caution must be exercised that adequate time must be allowed before the bushes are plucked, so as to ensure that the flush is all new growth formed after the application of the spray. Lead Chromate is a most commonly recommended insecticide in North-East India against various caterpillar pests of tea. It possesses the advantages of being non-arsenical, fairly cheap and of having no deleterious action on the bushes, while its yellow colour renders it easily visible. It sticks to the foliage well and although not so poisonous as arsenical mixtures, is yet excellent for planting insects.

Spraying, to be effective at all, must be undertaken as soon as the damage is first noticed when the pest could be kept in check even in a small area.

The third stage of the insect, *viz.*, the pupa, is the most vulnerable stage of the pest and any control measures directed against this stage would to a large extent prevent the recurrence of the pest in later years. The pupa as already mentioned is found underground around the base of the tea bush and by hand-forking the bushes and collecting the pupae, a really effective check could be maintained. This work should be continued in every affected area as long as the pest remains on tea; later when the last brood of caterpillars has disappeared

with any signs of pest anywhere on the estate, a thorough search must again be instituted over every part of the affected zone and the pupae thus collected destroyed. It may be found during this collection that only a few pupae could be collected in spite of a careful search but these are of immense importance in so far as they are the only survivors of the pest (with the probable exception of eggs alluded to before) which, if left undisturbed, would start the pest again in the coming year.

The destruction of the moths is just as important as that of the pupae, if not more so. The habits of the moths render the work of their destruction comparatively easy, they are very sluggish and rest during the day with outstretched wings on the trunk of *Grevilleas* and other tall trees on the estate. They are rather apt to be over-looked at the first sight since their colour resembles closely that of the bark of the *Grevilleas*, but an eye once trained to seeing them cannot fail to detect them. The moths may be collected in very large numbers and destroyed and may be beaten with sticks on the *Grevillea* trunk itself. A very large number of them could in this way be dealt with, but in view of their habit of resting as high as 20 feet or more, some of them are bound to be out of reach of the cooly's hand. This is no doubt a draw-back but, it should be remembered that the destruction of one moth may mean the removal of several hundred caterpillars of the next brood. A large percentage, however, can be dealt with at a very low cost and its value is appreciable. To make up for any deficiency that may result in carrying out this method, a later collection of pupae is urged. I have very little doubt that a combined programme of collection and destruction of moths and pupae, systematically applied, would help materially in reducing the ravages of this pest to the barest minimum. Instances are on record in N. E. India where this pest has been almost entirely eradicated on estates by the adoption of the above measures over a number of consecutive years.

Natural enemies:—As natural enemies of the pest, a few predators and parasites have been observed, but to what extent they exercise a check on the pest, it has not been possible to decide at present with any great degree of accuracy. Birds have been observed to feed on the caterpillars and pigs search and pick up the pupae from the soil beneath the tea bush. Of the parasites, mention may be made of a tiny *chalcid* which was found to parasitise the eggs of the looper moth. In one of the egg-masses collected on the estate, an appreciable number of eggs was found parasitised. Dipterous parasites have also been found to attack the caterpillars.

To re-capitulate the fore-going account of control:—

1. Removal of eggs by hand collection or by the employment of an insecticide is not considered a practical measure and the degree of success can hardly be expected to be commensurate with the expenditure.
2. Collection and destruction of caterpillars may be useful in the very early stages but when the out-break has taken a severe turn, this measure is of no avail.
3. Spraying against caterpillars is of limited value. It is an advantageous expedient when the infestation is confined to a small area. In larger areas and after considerable damage has been done, it is not economical.
4. Collection of pupae is of utmost importance. A round of systematic and thorough search of the affected areas after the pest has disappeared for the season is emphasised.
5. Destruction of moths is of importance equal to, if not greater than, that of the pupae.

6. Lastly, a combined programme of systematic collection and destruction of pupæ and moths would help very materially in reducing the ravages of this pest to the barest minimum.

Bark-eating Borer:—A species of *Indarbela* was once reported as causing more or less serious damage on an estate in South Travancore. Some fields were so badly infested that most of the bushes in them could be seen with innumerable borer holes. A much harder pruning than was otherwise necessary had to be undertaken in order to remove the tunnels and the diseased scars made by the borers.

The attack was chiefly made on bushes rendered weak as a result of Pink Disease, Branch Canker, no manure or other causes and on those full of old knots, cracks, pruning snags etc. The new wood was not generally preferred by the caterpillar and since 'leggy' bushes full of knots and 'crows-feet' offer favourable situations for the moth to lay its eggs, it became clear at once that the cleaner and straighter the growth of the bush, the less danger there is of an attack by the bark-eating borer.

In view of the above circumstances, emphasis must be laid on a good and careful pruning as this will do much to lessen the liability of the bushes to attack. After an attack has taken place, control is best undertaken during pruning time as the affected branches could then be easily cut out and burnt. Subsequently, the pruned bushes are treated with an alkali wash, such as a 2% caustic soda wash, which softens the bark and at the same time may prevent the deposition of eggs on the treated bark. Such a treatment was undertaken on the estate but the result is not yet available.

Attempts made to obtain some knowledge of the life-history of the pest have not been very successful. The difficulty is mainly due to the long time taken to complete a life-cycle, associated with the fact that, being a borer, it is not easily amenable to rearing in captivity.

Scale Insects:—Brown bug (*Lecanium hemisphaericum*, Targ.) was the most conspicuous of the scale insects received during the year, having been frequently reported as causing more or less serious damage. Instances of *Ceroplastes* Sp., *Aspidiotus destructor*, Sign. and *A. Camelliae*, Sign. also came under report but were not sufficiently serious to cause anxiety. But in view of the increasing prevalence of Brown bug in certain districts, a short note on the pest may be given here.

The Brown bug has for long been known in all parts of South India as a comparatively serious pest of Coffee. It is of a universal occurrence in the tropics where it thrives on a very large number of plants both cultivated and uncultivated. Its first report on tea in India was made by Dr. Watt in 1895, although it is probable that the insect was in existence in India at a much earlier date.

In its adult stage, Brown bug is easily recognised by its snuff-brown colour and almost hemispherical shape. In its earlier stages of growth it often becomes difficult to distinguish it as it bears a close resemblance to the young of the green bug (*Lecanium viride*, Gr.). Immature Brown bugs are either dark pink or completely yellow. When of the former colour they are easily recognised but when yellow, their shape has to be taken into account and should be a short oval instead of elongated. Half-grown specimens can be distinguished by the presence of a branched ridge on the back somewhat resembling an 'X', elongated vertically. The male is an exceedingly rare insect. It has a smaller and more elongated

scale, never becoming spherical, and when mature is almost transparent revealing the pink chrysalis which in time gives forth its minute winged insect.

Details of life-history of the pest as attacking tea has not been worked out, but as worked out on Coffee, it would appear that the total number of days from the time of hatching to the time when the young emerge range from 70 to about 83 days. The number of days during which the young continue to emerge from under the mother has been found to be about 16 in the case of a large bug which laid 684 eggs.

From the few records of outbreaks reported from time to time we are not in a position to determine its exact status as a tea pest and it would be necessary for this purpose to carry out investigations into the aspects of its distribution and severity in the affected districts. The bug feeds on the leaves, twigs and shoots and there can be no doubt that, if present in large numbers, it is capable of doing considerable damage to tea by sucking the juices from the twigs on which they cluster, thereby preventing the production of flushing shoots.

Based on the investigations conducted on Coffee and taking into consideration the condition of tea cultivation, the following methods of control may be suggested.

If the attack is localised and confined only to a few bushes, the latter may be carefully brushed with Kerosene Emulsion or Fish-oil-Resin soap at a strength of 4 lbs. to a Kerosene tin of water.

Where the pest threatens to be serious, spraying with Fish-oil-Resin soap at a strength of 2 lbs. to a kerosene tin of water may be undertaken.

In case the pest is found securely established and giving indications of expanding, Watt and Mann, writing about the pest in N. E. India, recommend firing the plot, contending that it is more economical to lose the bushes than risk a wide distribution of the pest. This treatment is perhaps too drastic and if spraying with Fish-oil-Resin soap as suggested above be carried out carefully, it is considered that there may not be any great need for resorting to firing.

If the field is due for pruning, it may be pruned and the prunings burnt on the spot. In no case should the prunings be left in the field nor should they be carried to any other locality as there is always a danger of spreading the pest from one place to another.

Brown bugs have a few natural enemies. Studies on Coffee Brown Bug have revealed an Hymenopterous parasite attacking the bug and the maggots of a fly and the larva of a moth, *Enblemma* Sp. preying on its eggs. None of these is considered an efficient check. In the case of tea, however, specimens have frequently been received exhibiting signs of heavy parasitisation by a small Hymenopteron but it is not certain as to what extent the parasite keeps the pest in check in the field. No instances of other parasites or predators have come to notice.

Thrips.—The 'Thrips' reported last year on tea were conspicuous by their absence during the year under report.

The thrips attacking tea flowers in South India is now known to be *Thrips florum*, Schmutz, a different species to those occurring in N. E. India and Java on the flowers of Tea.

Of the other species reported previously as occurring on the leaves apart from *Heliothrips haemorrhoidalis*, Bouche, it is now found that four more species are involved. They are *Scirtothrips*, sp. (probably new), *Scirtothrips ? dorsalis*, Hood *Thrips* sp. and *Neoheegeria* sp. (probably new).

Ereboenis saturata, Meyr. This Pyralid reported previously for the first time in Central Travancore is now known to include within its range South Travancore also, where on an estate it was found abundantly distributed. Although it has not so far caused any wide-spread damage, it seems undesirable to allow it to go unchecked. The description of the pest and the method of its control may be consulted in an article published in the Planters' Chronicle of 26th January 1935.

SHADE TREES.

Albizzia:

Terias hecabe, Liun. was prominent on the Experimental Station during April – May, but its activities were subsequently checked to a very marked extent by the appearance of parasites. Two parasites were involved; one was a Braconid attacking the larva and easily recognised by its bright yellow cocoon constructed on the bare leaf-rib of the plant and the other was a pupal parasite, probably a species of *Brachymeria*. Over 80% of the larvae were found to be parasitised by either of the two parasites but the check exercised by the Braconid larval parasite was by far the greater.

Enplecrus sp. was the third parasite whose occurrence on *Terias* sp. was noted in a consignment received from the High Range.

The caterpillars of a Noctui moth, *Rhesala maestalis* Wlk. was once found infesting *Albizzia* seedlings.

A small yellowish caterpillar giving rise to a tiny, shining black moth (as yet undetermined) was also observed to be prevalent during April–May feeding between two leaf-lets.

Grevillea:

The weevil borer was the most prominent of the pests of *Grevillea* reported during the year. It was received from an estate in North Mysore, where it was stated to have caused extensive damage over the last few years. It is a new species of weevil identified as *Pagiophloeus unbricidus*, Mrshll., by the British museum and a study of the pest, was undertaken. The following is a short note on the subject.

Depredation:—The depredation takes the form of boring in the wood immediately below the bark. No definite tunnels or galleries of the type usually met with in the case of a caterpillar and other beetle borers are excavated and no borings are voided off at any pre-formed exit-hole. A mass of digested wood and excreta is usually found pressed against the inside of the bark and the grub takes a tortuous course round the branch or stem of the affected tree. In view of the concealed nature of the damage it becomes difficult to detect the pest in its early stages. It is only when the damage is extensive and the branch shows signs of withering that one gets the first indication of the borer activity.

The age of trees appears to have a definite bearing on the attacks of this borer. Observations made on this point seem to indicate that trees from 2 to 5 years old are liable to attack while older ones remain immune. This may be probably due to the fact that the harder and more resistant wood of the older trees and the larger quantities of gum present in them produce unfavourable conditions for boring.

The activities of the pest appear to be confined to the latter half of the year but what becomes of the pest from January to June is still obscure. It is possible that the eggs laid during October–December may remain dormant till

the following July, or that the grubs may be in their very early stages during these months, when damage done by them is not easily detected.

Life-history.—The life-history of the pest has not been worked out. The eggs and the sites chosen for egg-laying have not been discovered. It is presumed that October–December is the period of egg-laying, but definite observations are necessary on this point. During the examination of the affected branches received here, it was noticed that the attack was mostly confined to the immediate neighbourhood of the axils or forks of branches. These are perhaps the most likely places where eggs are laid from which the larvæ on hatching bore through to the inside of the branch.

Nothing is known about the duration of the larval period nor the habits of the larva.

Pupation takes place inside the larval burrow but what time is spent as pupa and whether any hibernation takes place in this stage remain to be investigated.

The emergence of adult weevils is believed to take place from September to December. The habits of the adult weevils and the number of broods a year require determination.

CONTROL:

1. *Collection of weevils*.—During the flight period of adults every effort should be made to collect and destroy the weevils. How exactly it should be done is rather difficult to suggest at present in the absence of precise knowledge of the habits of the weevil. From the fact, however, that the main stem is more often attacked than branches, it might be concluded that the adult weevil is a low flier.

2. *Prevention of egg-laying*.—The time and places of egg-laying are important considerations about which we have no information at present and the necessity for investigation in this direction must be stressed as possibly providing very useful clues for undertaking preventive measures.

The form of control against this class of pests should be more of a preventive nature than remedial. Any attempts undertaken during the egg-laying season to protect all situations that afford suitable places for the weevils to lay their eggs would be of definite value. This could be done by the timely application of a suitable wash such as that of Tar Distillate or Carbolineum to the stem and axils of branches, if crevices on these are chosen for egg-laying; but it should be ascertained by a preliminary trial that the wash chosen for this purpose does not injure the bark.

3. *Removal of infested trees and branches*.—If the infestation has taken a severe turn, no course can be adopted other than the cutting and destruction by fire of all infested trees or their branches.

4. *Application of Tar Distillate to the bark*.—This can only be of limited advantage. It might prevent oviposition or even kill the eggs if the application synchronises with the oviposition period and might also deal with such of the grubs as may be still superficially boring. At other times, the grubs, lodged as they would be, beneath a felt of bored wood, would scarcely be affected by the emulsion.

With regard to the several borers reported previously as associated with the disease of *Grevilleas* in the Anamallais, identifications are now available of three. They are *Xyleborus semigranosus*, Bldf., *Platypus latifinis*, Wlk., and *Phaeno-*

merus sp. None of these, however, seem to be of any great significance so far as the particular disease is concerned.

'Cutworms', probably belonging to *Euxoa segetum*, were once reported as damaging nursery plants in the High Range. No information was however available as to what extent the depredation had taken place.

A *Clytrid* beetle, *Aspidolopha interruptofasciata*, Jac., was once found in very large numbers on young *Grevilleas* on the Experimental Station. No damage that could be attributed to the beetle was evident on the plants and its relation to *Grevillea* is still obscure.

Acacia:

Young plants of *Acacia decurrens* were reported from Nilgiris as being defoliated by the weevil, *Mylocerus subfasciatus* Guer. It is a common weevil attacking a variety of plants in South India but it is the first instance that has come to the knowledge of this Department of this weevil attacking *Acacias*.

RED GUM:

Excepting two instances, one of a weevil, *Mylocerus viridanns*, F., found feeding on the leaves, and another, of an Eumolpid beetle, *Tricliona picea*, Jac., of doubtful significance no further insects than those reported last year have been observed on these trees.

COLLECTION:

Progress in the representative collection of insects occurring on tea, shade trees and green manure plants has been maintained. A note requesting insect material was sent at the beginning of the year to all district associations for circulation amongst their members, with a view, firstly, to augment the Station collection and secondly to have a better knowledge of the distribution of the various insects in the different tea districts. The response however has been very poor.

REPORT OF THE MYCOLOGIST.

Advisory.—Eighty-nine consignments of plant specimens were received. A few of these included plants for identification with a view to recommendation as cover crops or as selective weeds. The identification of these plants has been carried out as far as possible, to the genus to which they belong.

The majority of the diseases concerned tea while specimens from diseased shade trees and others have also been reviewed. From the descriptions accompanying the diseased samples it has not been possible to gauge the intensity of such attacks. Detailed descriptions are necessary to formulate control measures especially when the outbreaks are serious or tend to become serious.

Mention must be made of two apparently new diseases of tea in South India viz., the *Cercospora* leaf disease and the *Violet Root Rot*. These diseases have been reported from elsewhere, but have so far evaded recognition here. Reference in greater detail will be made to these later.

Nursery diseases appear to be receiving greater attention. Eelworms have been, as usual the most common cause of damage to the seedlings. Some specimens though free from these worms or other pathological organisms but yet presenting an unhealthy appearance have been frequently received. Damage appeared to be due in these cases either to change in climatic conditions or to adverse soil conditions or both.

A few enquiries unaccompanied by specimens were received and the information required has been supplied.

A report was also made on two specimens of Rubber leaves affected by the mildew fungus—*Oidium*.

Soil Acidity: Acidity determinations of nearly a hundred and twenty soils were made during the season.

LEAF DISEASES:

The Cercospora Leaf Disease: Formerly only Ceylon recorded this disease but with the receipt of specimens of diseased leaves from the High Range during the S. W. monsoon its presence in South India must also be acknowledged.

It was not possible to ascertain from this sample the nature of damage since by the time the leaves arrived all of them had dried and were uniformly brown. At about the same time a few bushes bearing diseased foliage were observed on an estate adjacent to the Experimental Station. On this collection brown circular patches bearing resemblance to the spots of Brown Blight were evident, but the patches in this instance were more circular and they were marked by the absence of any zonation so characteristic of Brown Blight infection. Some of these patches had fused and the older ones were greyish instead of brown.

Since the bushes had been pruned a few months previously it was not possible to assess the effects of the disease on the bushes. The following however was the description accompanying the specimens from the High Range "The curious thing about the disease is that the younger leaves (not the flush) are attacked and then they fall off leaving the bush with bare young wood but for recent buds". In Ceylon where the disease has been the cause of some concern the fungus (*Cercospora theae*, Petch) has extended its activities to the flush also with the result that the twigs appear entirely defoliated.

Highly humid conditions appear to be necessary for the propagation of the fungus and the disease has been noticed during the rainy season when periods

of mist usually occur which produce the required humidity. The disease ceases to be serious with the advent of dry weather although it does not entirely disappear.

The disease in Ceylon has generally been associated with the planting of *Acacia decurrens* as shade. *Albizzia lophantha* is also one of the hosts of the causal organism. Its spread to tea is reported as being effected by the fall of affected leaflets of these shade plants on the tea foliage. Owing to their small size they adhere to the tea leaves during moist weather and infection commences at the point of adherence. Dispersal is also effected by wind blown spores of the fungus, the spores (the conidia) being capable of germination in rain water.

The fungus has also been recorded on two species of Red gum plants viz. *Eucalyptus robusta* and *E. diversicolor* also on *Acacia dealbata* and *A. melanoxylon*.

Infected leaves when examined with a lens show a cobwebby mycelial growth on the diseased circular spots. The mycelial growth is scanty and may not in some instances be discernible. The spores (conidia) are produced on these spots either directly or on the branched conidiophores. The mycelium is septate and branched. Some of the branched threads carry at their extremities the conidial fructification on similar but more profusely septate stalks called the conidiophores which carry three to six septate, club shaped, colourless (hyaline) spores called the conidia which are easily separated from their stalks by wind. Primarily the infected spots are small but these enlarge in size and often fuse together.

Apart from the conidial fructification described above, *Cercospora theae* appears to produce a second perithecial type of fruiting body containing within the reddish brown sac asci and ascospores. It has been considered that the fungus winters in this condition. So far perithecia have been observed only when the fungus has been artificially cultivated, those occasionally produced on naturally infected leaves remaining empty without producing the asci and spores.

Attempts at isolating the fungus were successful. Spore suspensions from the diseased material were transferred to agar media and these resulted in pure growths of the fungus being obtained. Within a week conidia were profusely produced on the surface of the medium with little or no growth of the mycelium. The development of the mycelium appeared to depend upon the nature of the medium employed. Where mycelial growth was abundant the spore production was delayed for sometime.

In culture the mycelial growth was at first colourless but gradually the growth turned reddish brown. Often the mycelial threads were found to group themselves into a compact mass like the sclerotial bodies produced by certain fungi. The older mycelial threads exhibited numerous spherical swellings along their length and such hyphae resembled the chlamydospores that are observed in the case of *Fusarium* and others.

Conidial production did not differ much from its production in nature, the spores being formed both directly from the ends of hyphae and on branched conidiophores. Most of the conidio spores were three septate in the beginning but with age the septation increased to four, five or six. The size of the spores did not show much variation from those naturally produced on infected specimens. One curious feature of these conidia was that some of these with age developed spherical or oval swellings between the septa. Two or more such swellings have been met with in some of the spores during their examination. The significance of these swellings has not been yet understood and no mention appears to have been made of such formations from the countries that have reported

this fungus. Germination of the spores took place in rain and filtered tap water, often more than one germinating tube developing from each spore although these were from different cells.

Mention was made of the existence of a Perithecial stage of *Cercospora*. Several attempts were made to produce them artificially on agar media, sterilised bean pods and green twigs and leaves. On some of these reddish brown spherical fleshy masses, resembling perithecia, developed, but in none of them was any spore formation observed. They were for the most part filled with globules of an oily or fatty nature. In Ceylon Dr. Gadd has reported that the perithecia produced on his artificial culture contained both asci and ascospores.

With a view to comparing the local strain of *Cercospora* with the Ceylon organism cultures of the latter were obtained by the courtesy of Dr. Gadd. Conidial production has not shown any difference. Attempts were made to observe if fertile perithecia could be obtained from the Ceylon strain but so far these attempts have not met with any success. Again, in this direction there was no difference between the two strains. Further attempts are being continued by varying the media to see whether it is practicable to obtain them under our conditions.

The exact status of this new fungus disease in South India is not known. Since, however, the disease appears to have made its appearance in this country control measures instituted during the early stages should sufficiently ward off the disease from establishing itself in its new environs. In Ceylon, as observed already, from the Mycological point of view the planting of susceptible host trees has been discouraged. Spraying on an extensive scale has been viewed as impracticable, but, since the disease has just made its appearance in South India, it is felt that spraying the bushes might be of value in preventing the disease from spreading. As with any other fungus disease, affected leaves and twigs should be burnt.

Sooty Mould: Specimens of tea leaves covered with a black or greyish black layer of a fungus on either surface have frequently been received. The fungi responsible for the development of such a covering on the normally green leaf surface have been collectively termed the 'sooty moulds' and comprise many different fungi belonging to various groups. Owing to their uniformly producing this disfigurement of the leaves, it has not been customary to treat them individually. On the specimens that were reviewed during the year a species of *Capnodium* was more common than any other.

The majority of the 'sooty moulds' do not cause any direct damage since these, instead of feeding on the tissues of the host, live on the sweet exudations that are deposited on the leaf surface by scale insects and others. The fungus feeds on the honey dew secretions and immediately the food is exhausted, the black fungal covering falls off in flakes from the surface. Such growths however indirectly interfere with the activities of the foliage by preventing photosynthesis and transpiration from proceeding normally. Such of the moulds that feed on the honey dew secretions are known as the "real" sooty moulds and occur mostly on leaves. A few other moulds that produce a similar effect on branches are termed the "spurious" moulds since they feed on the scale insects themselves and not on their secretions.

In devising control measures therefore the aim should be to destroy such insects that secrete the "honey dew". Ants are some times responsible for the distribution of the mould and therefore where ant nests are present either on shade trees or on the tea they should be destroyed by burning. This should be followed by spraying sooty mould infected bushes with an insecticide such as

fish-oil resin soap to destroy the scale insects attracting the moulds. These measures should be able to eliminate successfully the damage from sooty mould infection.

Leaf Scab:—Tea bushes often show a mottled colouration in some of the older leaves. The leaves at first show on the upper surface a black colouration in patches, these patches gradually turn yellow or brown or exhibit a mixture of all the three colours. On the lower surface of such leaves translucent oily patches are discernible; and the entire leaf, instead of being smooth and soft to the touch, becomes hard and brittle. Where the patches have become brown and are drying out the surface cracks irregularly. Examination of such leaves usually show no particular organism although spores of Brown and Grey blight organisms may be present. In some instances the leaves will have become corky irregularly. The foregoing symptoms are generally referred to as 'leaf scab'. It is thought that the disease is not due to any pathogenic organism and instances of scab are present perhaps on all estates though nowhere has it assumed any serious aspect.

Witches Broom disease:—In the annual reports for 1933-34-35 this disease of the tea bush was described and its cause was attributed to a deficiency of sulphur. Last year it was reported that some bushes had been treated to supply this deficiency. Although in the early stages the treated bushes appeared to develop normal foliage, subsequent growth has indicated that the treatment requires further consideration.

Observations during the year have shown that the disease becomes manifest during dry weather. Entire bushes affected by this disease show no fresh growth except for some old leaves and dormant young buds which never develop into normal flush.

The disease has appeared on a few more bushes distributed in an irregular manner all over the Station area.

Other Leaf Diseases:—Brown blight infection on nursery plants has been of frequent occurrence since last year. Only a single instance of Black Rot was reported but there is no reason to believe from this that the disease has ceased to be of concern in districts where it obtained a hold. Lack of enquiries on this subject is probably attributable to planters being cognisant of the various symptoms of this disease. No other new or serious disease affecting the foliage of tea bushes has been reviewed during the year.

STEM DISEASES:

Pink Disease:—Only two specimens affected by *Corticium salmonicolor*, were received; paucity of enquiries regarding this disease is certainly not an indication of the disappearance or abatement of this disease.

Microscopic preparations made from affected tea branches clearly indicated the fact that the fungal mycelium is capable, as in the case of *Hevea*, of blocking the xylem pores (lumen). The fungus was observed on some Coffee branches.

Branch Canker:—Specimens of tea bushes with heavily cankered branches have frequently been received from an estate in South Travancore. So far examination of these specimens has not revealed the exact pathogen that is responsible for canker production. The cankers however resembled closely those produced when Pink disease infection was present. In the absence of any fungal growth on the affected branches, the cause of damage has not been established. The probability of climatic conditions bringing about such canker growths has been suggested, but this requires investigation.

Galls on Tea Branches:—The Entomologist while touring in South Travancore observed on some tea bushes the presence of gall-like excrescences.

When examined at the laboratory these curious growths showed no gall producing fungus. It is opined that these growths are the result of attacks from gall forming insects. Only stray bushes appear to have developed such growths. No particular control measures appear to be required.

Burrs:—Tea branches with spherical burr-like growths were also found by the Entomologist in the same district. These, when examined, indicated no organism, fungal or otherwise. Sections of these spherical structures demonstrated the presence of healthy wood in the malformed tissues. This also eliminates the possibility of insects or fungi being the cause. Petch on the analogy of similar growths on certain coniferous trees considered abnormal growth of the adventitious buds to be the cause and the alignment of the tissues in the burrs examined here appeared to confirm the above view. As in the case of gall growths no measures of control need be considered.

Velvet Blight:—A few tea branches covered by a brownish black layer of fungal growth were received from an estate in the Anamallais. The branches except for this superficial layer of velvety fungal growth were of a healthy appearance, the wood and even the bark exhibiting no indication of disease. The fungus was tentatively identified as a species of *septobasidium*. Specimens having such a growth were sent to the Imperial Institute of Mycology in London for confirmation and these have been identified as probably being *Septobasidium theae* Boedijn and Steinmann.

Since, in the specimens examined the branches were of healthy appearance, the fungus was apparently not parasitic on the plant but was probably of an ectophytic nature. Similar growths occur when tea branches are attacked by scale insects. The fungus in such cases is parasitic not on the host plant but feeds on the insects. In other words they are entomogenous and beneficial. In the present instance the insect colonies were not clearly visible, although there were traces of a stray insect here and there on the branch. The fungal growth was however entirely superficial.

In order to remove the fungal growth rubbing the branches with sackcloth has been suggested. The application of a caustic wash after the removal of the fungal layer and the spraying of the bushes with Fish-oil resin soap to kill any scale insect colonies that might be present should prove beneficial. Caustic washes should however be applied only to the branches and preferably after pruning.

Macrophoma Theicola:—A suspected case of tea branch canker from this fungus occurred on an estate in the Nilgiris. This disease in its essential details i.e., the effects of infection resembles Pink disease which is so common in South India. As in the case of Pink disease the branches develop cankers and result in the damaged shoots dying back with withered foliage. *M. Theicola* is common in Ceylon and has probably the same status there, as Pink disease has in South India. The specimens under review were perhaps the only representatives of this disease that have been so far recorded here.

Control measures should follow the same lines as with attacks of Pink disease.

Wood Rot:—An instance of Wood Rot in tea bearing the black fructifications of *Hypoxylon vestitum* Petch, was reported from an estate. In addition to this fungus, the wood indicated signs of having harboured white ants probably of a scavenging type.

From an estate in the High Range a Wood Rot specimen bearing scarlet red fructifications of a fungus was received. The fungal growth was saprophytic. Since it was not possible to identify the growth here, it was submitted together

with a few other specimens for identification to the Imperial Institute of Mycology in London. The fungus has been identified as *Hydnum cinnabarinum* Schw.

ROOT DISEASES:

Attacks from *Rosellinia*, *Poria*, *Fomes*, *Ustulina*, the four common root rot organisms of South India have as usual been recorded from practically all tea districts. *Armillaria* had up to this year been noticed only in the High Range, although the disease has recently been observed on a few specimens of *Grevillea* that were received from the Nilgiri district, it is not yet established whether the fungus in the latter district has extended its host range to tea. The Velvet Blight Root disease (*Helicobasidium*) has fortunately limited its activities to some estates in Central Travancore and only a single specimen was received even from this district.

An apparently new disease of tea, in South India was brought to notice with the arrival of a few rotting stumps from an estate in Central Travancore. It is the Violet Root Rot and has been described in some detail below:

Violet Root Rot:—(*Sphaerostilbe repens*). This root disease of the tea bush was first recorded in N. E. India though the fungus had been known as causing root disease in Rubber, and other jungle plants notably the Jack fruit tree (*Artocarpus integrifolia*) all over the tropics. Subsequently however the disease was found prevalent in Ceylon and it has now appeared in South India also.

The disease manifests itself on bushes growing under bad soil conditions especially when the soil is clayish and illdrained.

Affected bushes appear sickly and take a long time to die. On digging out, the roots appear saturated with water—in other words they are water-logged, and impart a peculiar smell resembling vinegar. The bark is of a violet colour. Beneath the bark and on the surface of the wood are found long strands of a violet to bluish colour arranged radially. These represent the mycelial growth.

The fungus produces two kinds of fructifications on the exposed parts of the bush near the collar. The first form consists of short red stalks surmounted by a white head. The stalks are hairy. The head bears at its extremity the (imperfect stage) conidiospores. The second form of fruiting body is produced later and consists of small, dark red, flask-shaped bodies crowded together at the bases of the stalks or at other places whenever the mycelium is exposed.

Control measures against this disease should aim at improving soil conditions particularly drainage. Infected bushes should be pulled out and burnt. The treatment with lime that has been suggested in N. E. India is now replaced by treating the patches with Sulphate of Iron or Alumina, though no work has yet been done to determine whether or not the fungus prefers acid or alkaline conditions. It is intended to proceed with this work when suitable material becomes available. In the absence of definite information on this aspect of control, the other remedial measures should be executed carefully.

The preceding description of the disease is based mostly on the published records and on the observations made at the time the diseased roots were received at the Station. No information is as yet available about the precise conditions under which the disease occurs here.

Sulphate of Alumina and Root Disease:—A report of the efficiency of Sulphate of Alumina against Stump rot (*Fomes*?) has been received. Further work in the Laboratory with artificial cultures of *Poria* indicated that ordinary bazaar alum was equally capable of checking the growth of the fungus.

Nursery Diseases:—Eelworm has been the sole cause of damage in Tea nurseries, although a die-back of the shoots was recorded from a few estates. In the latter cases however, fresh growth resulted from the region of the collar. The Brown blight organism was manifest on the die-back shoots and on the withered foliage. Liberal application of manures, and where the intensity of die-back was great, the spraying of plants, were suggested.

The suggestion of beneficial results accruing from providing shade to Eelworm infested nurseries has been investigated in N. E. India. The percentage mortality of infected plants considerably decreased in the shaded area especially when in addition, the soil had received chemical treatment to reduce the population of nematodes.

Insufficient root growth due to bad soil conditions and consequent lowering of vitality of seedlings was responsible in some instances for the plants not growing well. For the plants to establish themselves a good loose soil and sufficient moisture are essential and these should be supplemented by a liberal dose of manure.

Tea Seeds:—A few consignments of tea seeds were received for determining their freedom from disease and capacity to germinate. The most common organism in the case of diseased seeds was a species of *Fusarium*. Although work has been done on this subject, no satisfactory explanation has been forthcoming as to how exactly the fungus appears within the seeds which apparently are sound. Various explanations have been offered but none explain the diseased condition convincingly.

Immediately after putting out the seeds the diseased ones emit a mouldy smell and the fungus itself appears on the shell as white patches. The infected seeds are advantageously removed and burnt to prevent the spread of disease. The application of fungicidal fluids—Formaline or Sulphate of Iron (2%) to the seed bed subsequently kills the fungus if present in the soil.

It is of importance to see that the atmosphere in a nursery is never too damp for it is under such an atmosphere that these otherwise less harmful fungi propagate.

Water Culture Experiments:—With a view to ascertaining the effect of withholding sulphur in any form on the growth of tea seedlings in water culture solutions, a few seedlings were grown. The acidity of the culture solutions (with and without sulphates) was determined by the Potentiometric method and the acidities were adjusted to about 3.64. The original solution in which the sulphur compounds were present indicated a degree of acidity equal to 3.64 on the pH scale while the solution devoid of this element had a lower acidity equal to 6.60, but the latter solution was rendered acid by the addition of dilute hydrochloric acid and the pH adjusted to approximate the original solution with the Sulphur compounds.

For about three months from the date of starting these experiments (18-11-34) seedlings in both the solutions grew without appreciable difference in their aerial leaf growth, but even after a few days after the start of the experiments the root growth in the two sets exhibited marked difference. Root growth in the normal solution with Sulphur (A) was prolific, many side roots having developed which were white and turgid. The shoots bore a good crown of leaves.

In the solution (B) devoid of sulphur compounds the roots were brown and flaccid. It is possible that the addition of HCl caused such a development, but since a similar flaccid brown growth was found developing in the solution

(pH 6.8) before the addition of HCl the cause of such growth has at present been attributed to the absence of sulphur in any form in the solution.

Gradually with the cessation of inhibited root growth in solution (B) the leaves failed to develop normally and the few that existed developed symptoms of a 'tip burn' the entire leaf finally withering and dropping off. As with the witches broom diseased bushes an imperfectly developed leaf bud was present at the end of the shoot.

Growth in solution (A) developed normally for a considerable period.

The solutions were frequently renewed and these were aerated by blowing in air with the help of rubber blow balls.

The above experiments will be continued varying the constituents to note the effect on the growth of seedlings.

Die Back of Dadap Stems:— A die-back of Dadap twigs and branches has been reported and an examination of such affected branches has always shown the presence of a species of *Fusarium* on them. Such 'die back' twigs have also been recorded in Ceylon and the same or a similar organism has been responsible for the damage. The generic identification alone has been possible while the species still requires determination.

It must be remembered that Dadaps are particularly prone to damage from wind and broken twigs are always a source of further injury by attacks from weak pathological organisms such as the *Fusarium*. These organisms gain entrance through the pruning cuts and cause the branches to 'die back'. Another source of injury is the system of lopping or pollarding either to keep the growth under control or to make use of the green material. These cut surfaces again offer lodgings to the fungus, which causes the damage.

Since any attempt to treat the wounded parts is rather expensive, the minimum amount of damage should be inflicted on the branches of these plants. Where the disease already exists the branches should be cut back to healthy wood and the larger wounds treated with tar.

The fungus has been isolated in order to carry out inoculation work whenever Dadap material becomes available.

Similar 'Die-back' with *Fusarium* growths on affected plants has been observed occasionally on *Cassia laevigata* plants. The fungus instead of appearing as small pustules as on Dadaps, was present as a thin orange sheet on the affected branches. The roots of the *C. laevigata* plants were found infected by *Armillaria* causing the splitting of the wood. It is possible that the *Fusarium* developed after the bush had been killed by *Armillaria*.

Grevilleas:—A branch canker disease of this tree was reported, but on the specimens received no fungal organism was evident, though from the nature of the canker growth, it might be attributed to Pink disease infection.

A Die-back of the younger twigs was noticed from specimens in the Anamallais but no fungus was present on the damaged branches. The several causes of 'die-back' of *Grevilleas* in this district were discussed in the report published after a tour undertaken to investigate the causes of the damage to *Grevilleas* occurring on estates in the Anamallais.

Armillaria attacks were observed on *Grevillea* roots from the Nilgiris. The disease had so far not been noticed in this district but was of concern in estates on the High Range. Red Root Rot of *Grevillea* occurred on an estate in the

Wynaads. The disease had also attacked some tea bushes growing in the vicinity of the diseased *Grevillea*.

Grevillea nursery plants have been found susceptible to attacks of Eelworms; affected seedlings exhibit all the symptoms shown by similarly affected tea seedlings and ultimately die.

Tung Oil:—(*Aleurites* spp.) A leaf disease of *Aleurites* caused by a species of *Pestalozzia* was recorded. Its susceptibility to attacks of Pink disease has been observed on the branches of a tree in the Station. The fungus in this case having attacked a single stem extended further and caused the death of a fairly thick branch. It has been observed on parts of the main trunk also. It is considered that the many lenticel openings on the branches and the trunk afford easy access for the fungus to establish itself easily. The death of the branch was brought about by a ringing of the attacked portion of the branch, the parts above having died as a result of insufficient water supply.

UNITED PLANTERS' ASSOCIATION OF
SOUTHERN INDIA

TEA SCIENTIFIC
DEPARTMENT

ANNUAL
ADMINISTRATION REPORT

FOR

1935-36



PRINTED BY THE MADRAS PUBLISHING HOUSE LTD.
MADRAS

1936